Answer Set Solving in Practice

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Systems: Overview

1. Potassco
2. gringo
3. clasp
4. clingo
5. clingcon
6. claspfolio
7. clavis

Potassco

Outline

Potassco

potassco.sourceforge.net

Potassco, the Potsdam Answer Set Solving Collection,
bundles tools for ASP developed at the University of Potsdam,
for instance:

- Grounder gringo, lingo, pyngo
- Solver clasp, claspfolio, claspar, aspeed
- Grounder+Solver Clingo, Clingcon, ROSoClingo
- Further Tools aspartame, asp{un}cud, claspre, clavis, coala, fimo, insight, metasp, plasp, piclasp, quontroller, etc

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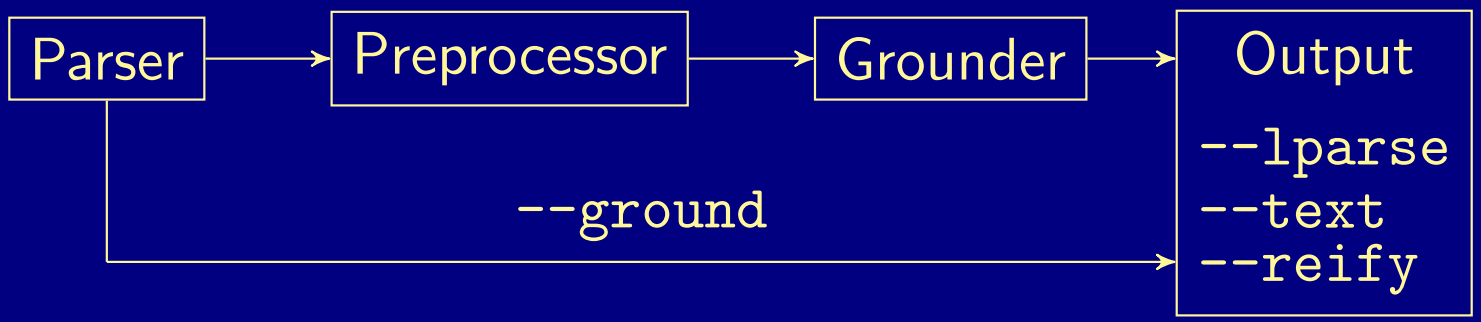
gringo

- Accepts safe programs with aggregates
- Tolerates unrestricted use of function symbols
  (as long as it yields a finite ground instantiation :)
- Expressive power of a Turing machine

- Basic architecture of *gringo*:



Potassco

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Potassco

clasp

- *clasp* is a native ASP solver combining conflict-driven search with sophisticated reasoning techniques:
  - advanced preprocessing, including equivalence reasoning
  - lookback-based decision heuristics
  - restart policies
  - nogood deletion
  - progress saving
  - dedicated data structures for binary and ternary nogoods
  - lazy data structures (watched literals) for long nogoods
  - dedicated data structures for cardinality and weight constraints
  - lazy unfounded set checking based on "source pointers"
  - tight integration of unit propagation and unfounded set checking
  - various reasoning modes
  - parallel search
  - ...

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Reasoning modes of *clasp*

- Beyond deciding (stable) model existence, *clasp* allows for:
  - Optimization
  - Enumeration (without solution recording)
  - Projective enumeration (without solution recording)
  - Intersection and Union (linear solution computation)
  - and combinations thereof
- *clasp* allows for
  - ASP solving (*smodels* format)
  - MaxSAT and SAT solving (extended *dimacs* format)
  - PB solving (*opb* and *wbo* format)

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Parallel search in *clasp*

- *clasp*
  - pursues a coarse-grained, task-parallel approach to parallel search via shared memory multi-threading
    - up to 64 configurable (non-hierarchic) threads
  - allows for parallel solving via search space splitting and/or competing strategies
    - both supported by solver portfolios
  - features different nogood exchange policies

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Sequential CDCL-style solving

```
loop
    propagate                          // deterministically assign literals
    if no conflict then
        if all variables assigned then return solution
        else decide                    // non-deterministically assign some literal
    else
        if top-level conflict then return unsatisfiable
        else
            analyze                    // analyze conflict and add conflict constraint
            backjump                   // unassign literals until conflict constraint is unit
```

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Parallel CDCL-style solving in *clasp*

while work available
  while no (result) message to send
    communicate // exchange information with other solver
    propagate // deterministically assign literals
    if no conflict **then**
      if all variables assigned **then send** solution
      else *decide* // non-deterministically assign some literal
    else
      if root-level conflict **then send** unsatisfiable
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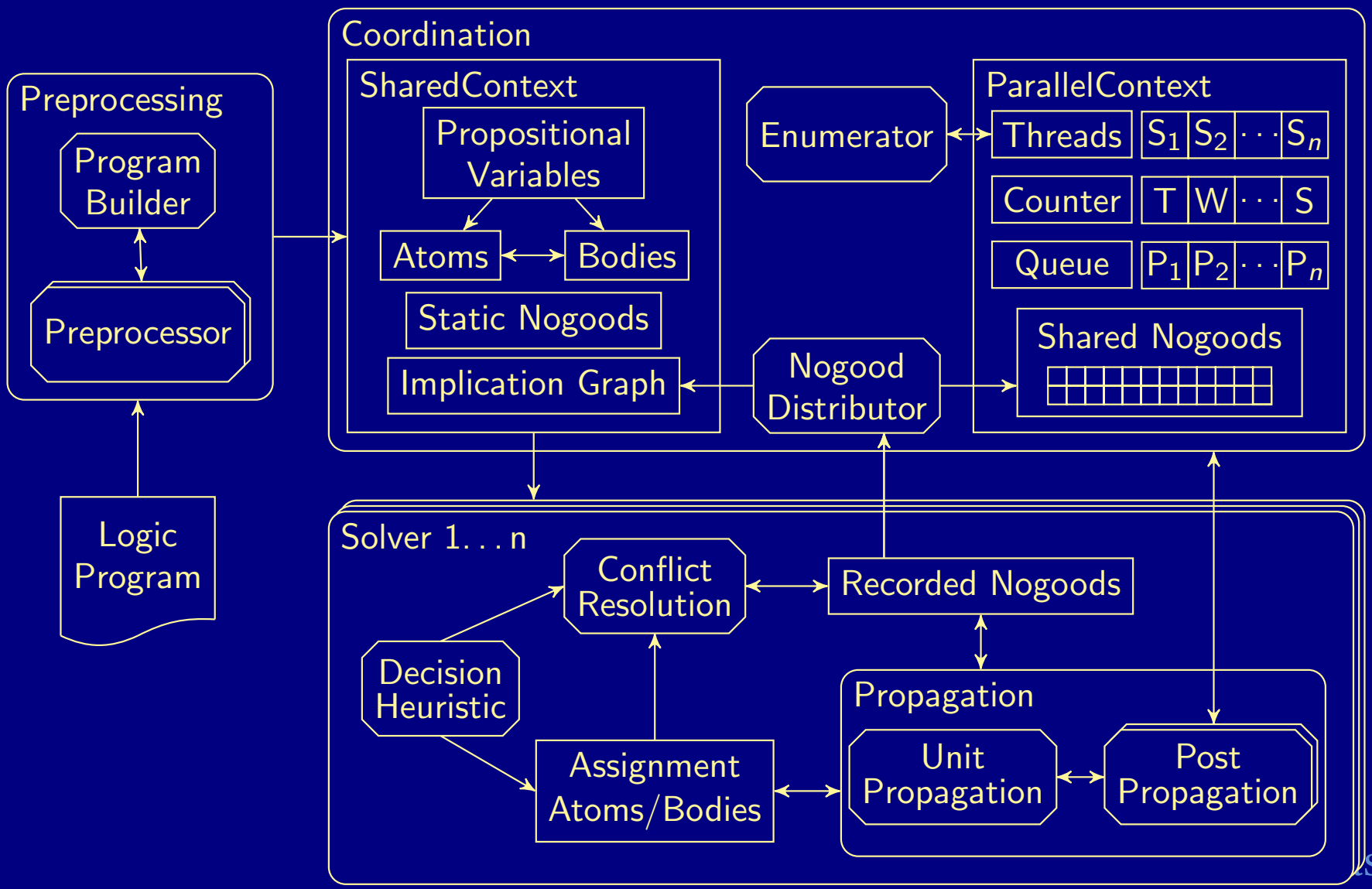
Multi-threaded architecture of *clasp*



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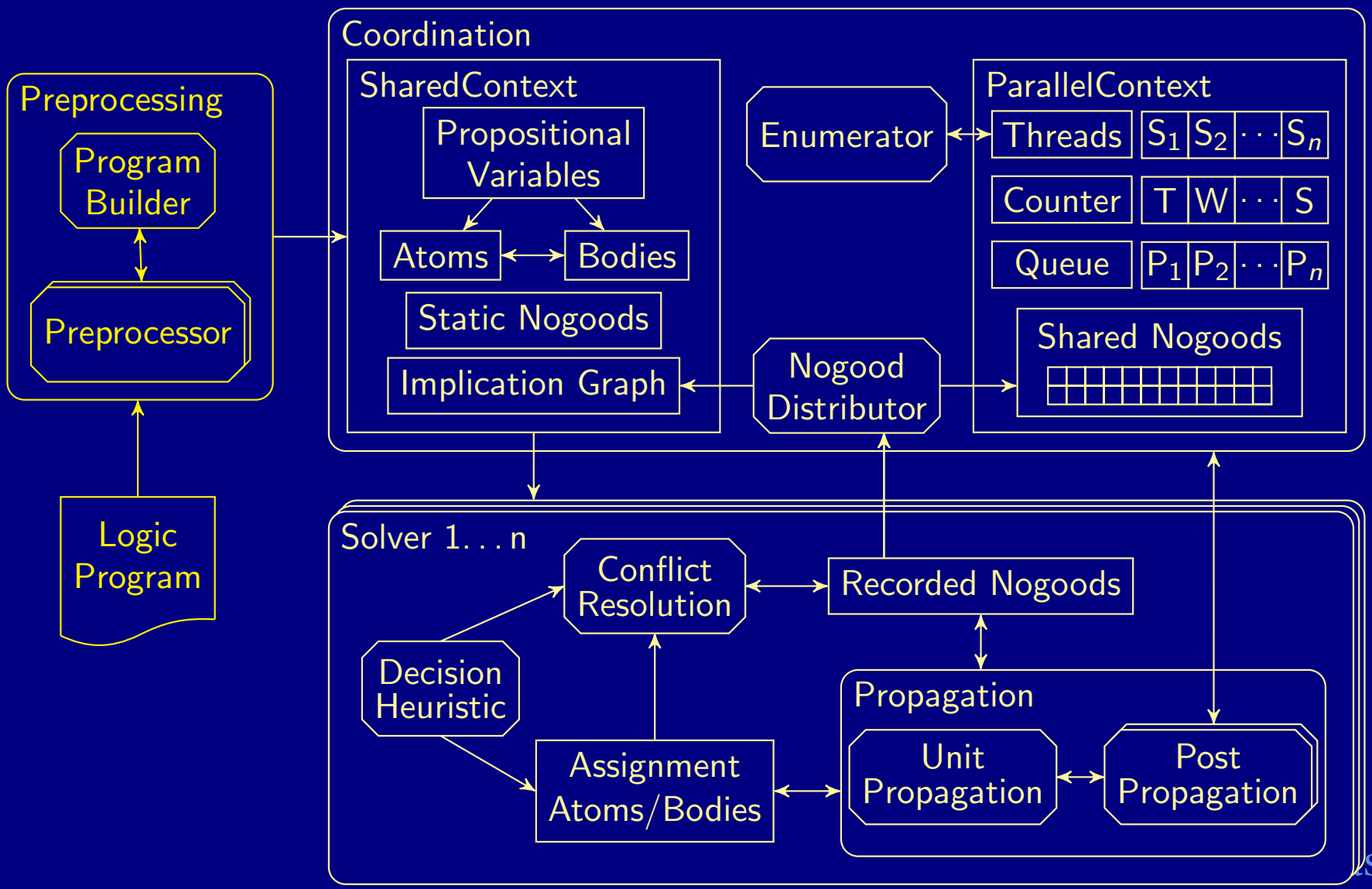

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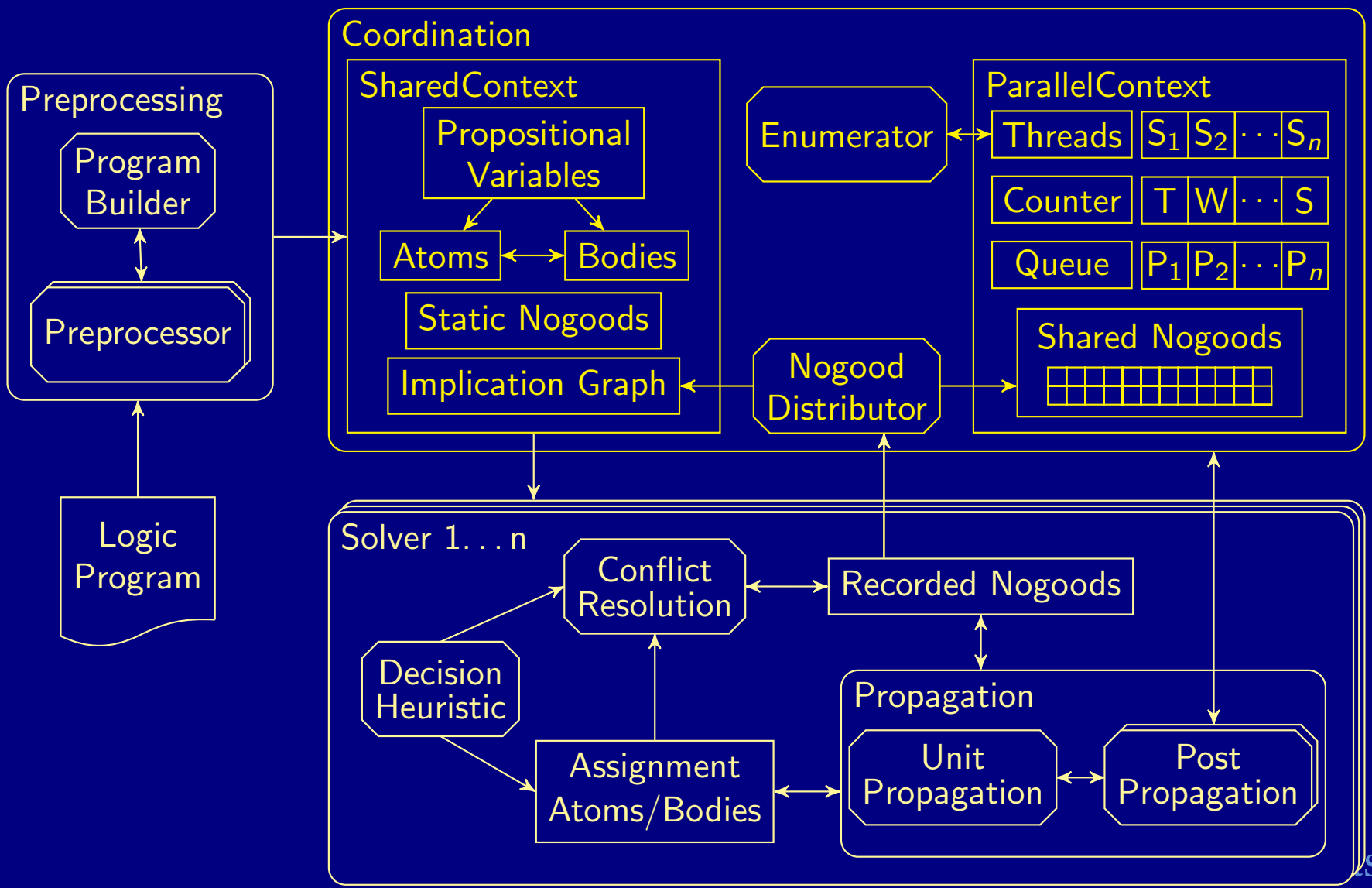

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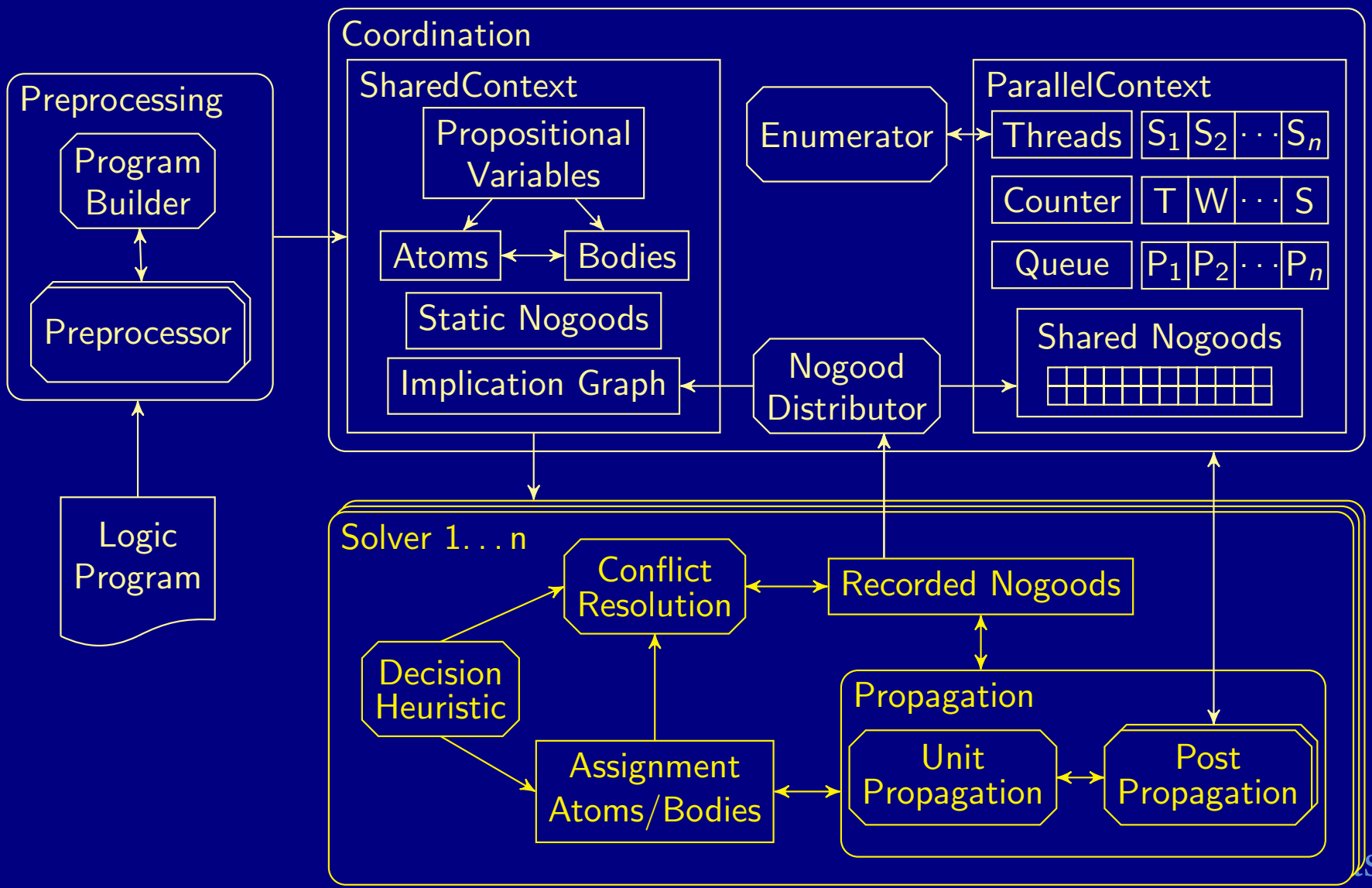

clasp in context

- Compare *clasp* (2.0.5) to the multi-threaded SAT solvers
  - *cryptominisat* (2.9.2)
  - *manysat* (1.1)
  - *miraxt* (2009)
  - *plingeling* (587f)

  all run with four and eight threads in their default settings
- 160/300 benchmarks from crafted category at SAT'11
  - all solvable by *ppfolio* in 1000 seconds
  - crafted SAT benchmarks are closest to ASP benchmarks

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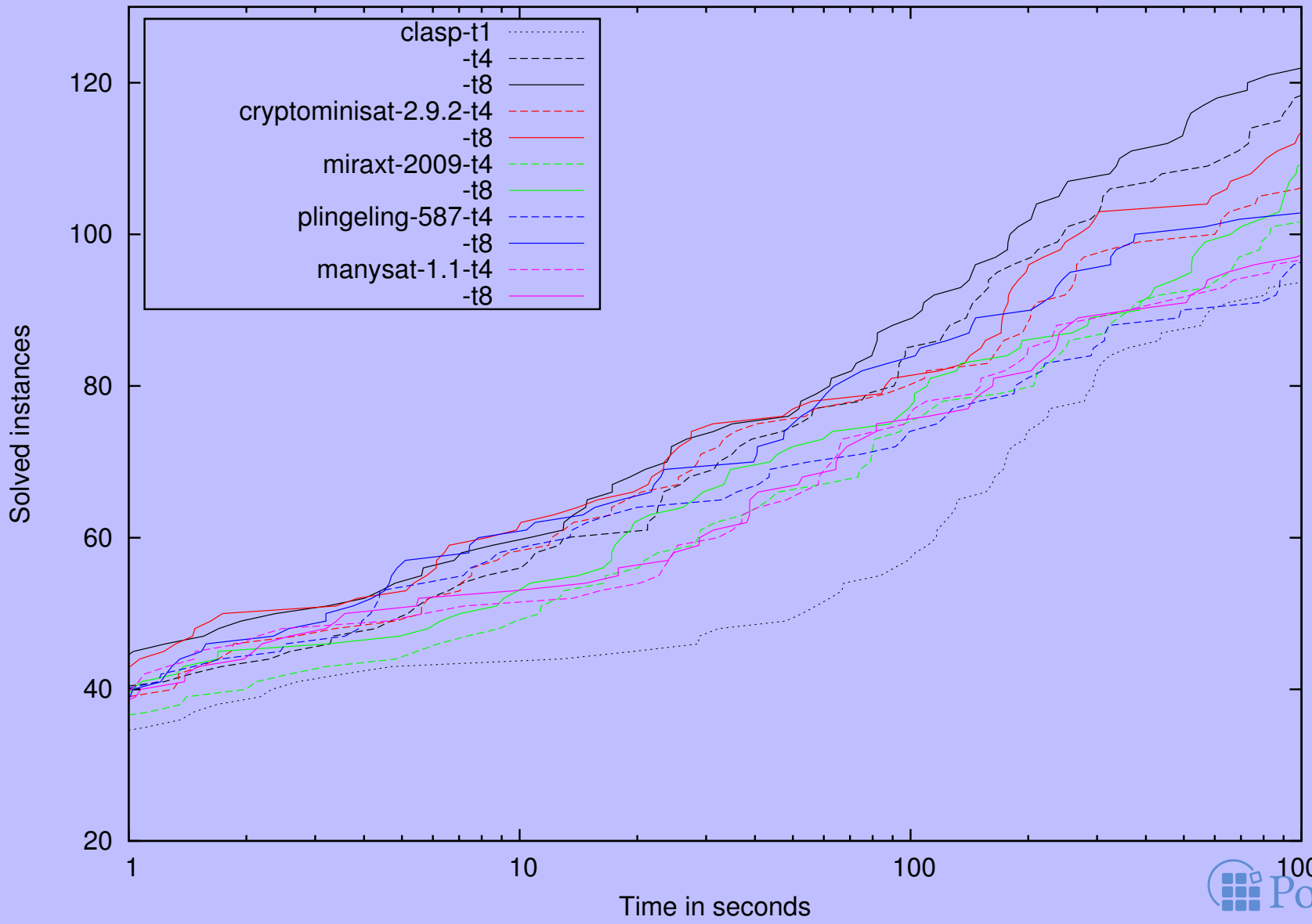
clasp in context



Outline

Using *clasp*

```
--help[=<n>],-h          : Print {1=basic|2=more|3=full} help and exit

--parallel-mode,-t <arg>: Run parallel search with given number of threads
    <arg>: <n {1..64}>[,<mode {compete|split}>]
      <n>   : Number of threads to use in search
      <mode>: Run competition or splitting based search [compete]

--configuration=<arg>    : Configure default configuration [frumpy]
    <arg>: {frumpy|jumpy|handy|crafty|trendy|chatty}
      frumpy: Use conservative defaults
      jumpy : Use aggressive defaults
      handy : Use defaults geared towards large problems
      crafty: Use defaults geared towards crafted problems
      trendy: Use defaults geared towards industrial problems

      "-t 4": Use 4 competing threads initialized via the default portfolio

--print-portfolio,-g     : Print default portfolio and exit
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Comparing configurations

on `queensA.lp`

n	frumpy	jumpy	handy	crafty	trendy	-t 4
50	0.063	0.023	3.416	0.030	1.805	0.061
100	20.364	0.099	7.891	0.136	7.321	0.121
150	60.000	0.212	14.522	0.271	19.883	0.347
200	60.000	0.415	15.026	0.667	32.476	0.753
500	60.000	3.199	60.000	7.471	60.000	6.104

(times in seconds, cut-off at 60 seconds)

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clasp's default portfolio for parallel solving

via `clasp --print-portfolio`

```
[solver.0]: --heuristic=Vsids,92 --restarts=L,60 --deletion=basic,50,0 --del-max=2000000 --del-estimate=1 --del
[solver.1]: --heuristic=Vsids --restarts=D,100,0.7 --deletion=basic,50,0 --del-init=3.0,500,19500 --del-grow=1.
[solver.2]: --heuristic=Berkmin --restarts=x,100,1.5 --deletion=basic,75 --del-init=3.0,200,40000 --del-max=400
[solver.3]: --restarts=x,128,1.5 --deletion=basic,75,0 --del-init=10.0,1000,9000 --del-grow=1.1,20.0 --del-cfl=
[solver.4]: --heuristic=Vsids --restarts=L,100 --deletion=basic,75,2 --del-init=3.0,1000,20000 --del-grow=1.1,2
[solver.5]: --heuristic=Vsids --restarts=D,100,0.7 --deletion=sort,50,2 --del-max=200000 --del-init=20.0,1000,1
[solver.6]: --heuristic=Berkmin,512 --restarts=x,100,1.5 --deletion=basic,75 --del-init=3.0,200,40000 --del-max
[solver.7]: --heuristic=Vsids --reverse-arcs=1 --otfs=1 --local-restarts --save-progress=0 --contraction=250 --
[solver.8]: --heuristic=Vsids --restarts=L,256 --counter-restart=3 --strengthen=recursive --update-lbd --del-gl
[solver.9]: --heuristic=Berkmin,512 --restarts=F,16000 --lookahead=atom,50
[solver.10]: --heuristic=Vmtf --strengthen=no --contr=0 --restarts=x,100,1.3 --del-init=3.0,800,9200
[solver.11]: --heuristic=Vsids --strengthen=recursive --restarts=x,100,1.5,15 --contraction=0
[solver.12]: --heuristic=Vsids --restarts=L,128 --save-p --otfs=1 --init-w=2 --contr=0 --opt-heu=3
[solver.13]: --heuristic=Berkmin,512 --restarts=x,100,1.5,6 --local-restarts --init-w=2 --contr=0
[solver.14]: --no-lookback --heuristic=Unit --lookahead=atom --deletion=no --restarts=no
```

- *clasp*'s portfolio is fully customizable
- configurations are assigned in a round-robin fashion to threads during parallel solving
- `-t 4` uses four threads with `crafty`, `trendy`, `frumpy`, and `jumpy`

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[solver.9]: --heuristic=Berkmin,512 --restarts=F,16000 --lookahead=atom,50
[solver.10]: --heuristic=Vmtf --strengthen=no --contr=0 --restarts=x,100,1.3 --del-init=3.0,800,9200
[solver.11]: --heuristic=Vsids --strengthen=recursive --restarts=x,100,1.5,15 --contraction=0
[solver.12]: --heuristic=Vsids --restarts=L,128 --save-p --otfs=1 --init-w=2 --contr=0 --opt-heu=3
[solver.13]: --heuristic=Berkmin,512 --restarts=x,100,1.5,6 --local-restarts --init-w=2 --contr=0
[solver.14]: --no-lookback --heuristic=Unit --lookahead=atom --deletion=no --restarts=no
```

- *clasp*'s portfolio is fully customizable
- configurations are assigned in a round-robin fashion to threads during parallel solving
- `-t 4` uses four threads with `crafty`, `trendy`, `frumpy`, and `jumpy`

Outline

Potassco

clasp

- *clasp* is a multi-threaded solver for disjunctive logic programs
- aiming at an equitable interplay between "generating" and "testing" solver units
- allowing for a bidirectional dynamic information exchange between solver units for orthogonal tasks

clasp

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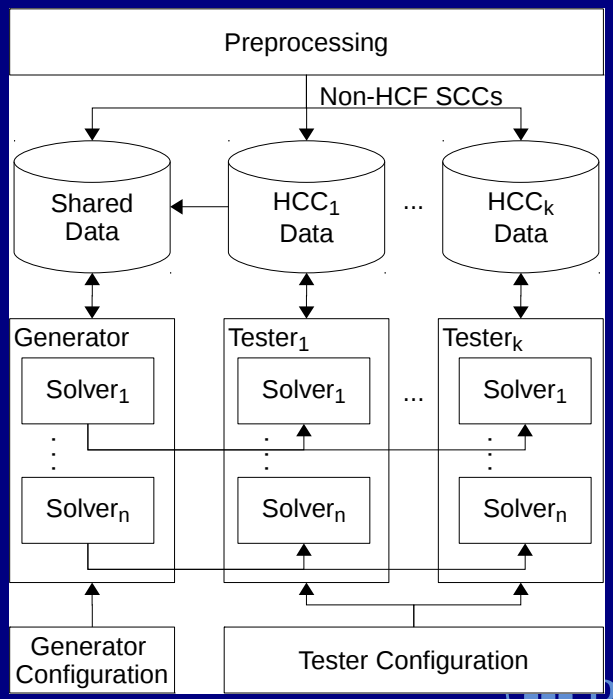

Outline

hclasp

- *clasp* allows for incorporating domain-specific heuristics into ASP solving
  - input language for expressing domain-specific heuristics
  - solving capacities for integrating domain-specific heuristics
- Example

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_heuristics(occ(A,T),factor,T) :- action(A), time(T).
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Basic CDCL decision algorithm

loop

propagate // compute deterministic consequences

if no conflict **then**

if all variables assigned **then return** variable assignment

else decide // non-deterministically assign some literal

else

if top-level conflict **then return** unsatisfiable

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analyze // analyze conflict and add a conflict constraint

backjump // undo assignments until conflict constraint is unit

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Inside *decide*

- Heuristic functions

$$h : \mathcal{A} \to [0, +\infty) \quad \text{and} \quad s : \mathcal{A} \to \{\boldsymbol{T}, \boldsymbol{F}\}$$

- Algorithmic scheme

1. $h(a) := \alpha \times h(a) + \beta(a)$ for each $a \in \mathcal{A}$
2. $U := \mathcal{A} \setminus (A^{\boldsymbol{T}} \cup A^{\boldsymbol{F}})$
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Potassco

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Potassco

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Potassco

Heuristic language elements

- Heuristic predicate `_heuristic`
- Heuristic modifiers (atom, *a*, and integer, *v*)

  `init` for initializing the heuristic value of *a* with *v*

  `factor` for amplifying the heuristic value of *a* by factor *v*

  `level` for ranking all atoms; the rank of *a* is *v*

  `sign` for attributing the sign of *v* as truth value to *a*

- Heuristic atoms

```
_heuristic(occurs(A,T),factor,T) :- action(A), time(T).
```

Potassco

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Potassco

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Potassco

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_heuristic(occurs(mv,5),factor,5) :- action(mv), time(5).
```

Potassco

Heuristic language elements

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- Heuristic modifiers (atom, a, and integer, v)

`init`	for initializing the heuristic value of a with v
`factor`	for amplifying the heuristic value of a by factor v
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- Heuristic atoms

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```

Potassco

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`level`	for ranking all atoms; the rank of a is v
`sign`	for attributing the sign of v as truth value to a

- Heuristic atoms

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```

Potassco

Heuristic language elements

- Heuristic predicate `_heuristic`
- Heuristic modifiers (atom, *a*, and integer, *v*)

`init`	for initializing the heuristic value of *a* with *v*
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`sign`	for attributing the sign of *v* as truth value to *a*

- Heuristic atoms

```
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```

Potassco

Simple STRIPS planner

```
time(1..t).

holds(P,0) :- init(P).

1 { occurs(A,T) : action(A) } 1 :- time(T).
 :- occurs(A,T), pre(A,F), not holds(F,T-1).

holds(F,T) :- holds(F,T-1), not nolds(F,T), time(T).
holds(F,T) :- occurs(A,T), add(A,F).
nolds(F,T) :- occurs(A,T), del(A,F).

 :- query(F), not holds(F,t).
```

Potassco

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nolds(F,T) :- occurs(A,T), del(A,F).

 :- query(F), not holds(F,t).

_heuristic(occurs(A,T),factor,2) :- action(A), time(T).
```

Potassco

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nolds(F,T) :- occurs(A,T), del(A,F).

 :- query(F), not holds(F,t).

_heuristic(occurs(A,T),level,1) :- action(A), time(T).
```

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_heuristic(A,level,V) :- _heuristic(A,true, V).
_heuristic(A,sign, 1) :- _heuristic(A,true, V).
```

Potassco

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 :- query(F), not holds(F,t).

_heuristic(A,level,V) :- _heuristic(A,false,V).
_heuristic(A,sign,-1) :- _heuristic(A,false,V).
```

Potassco

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```
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nolds(F,T) :- occurs(A,T), del(A,F).

 :- query(F), not holds(F,t).

_heuristic(holds(F,T-1),true, t-T+1) :- holds(F,T).
_heuristic(holds(F,T-1),false,t-T+1) :-
                fluent(F), time(T), not holds(F,T).
```

Heuristic modifications to functions h and s

- $\nu(V_{a,m}(A))$ — *"value for modifier m on atom a wrt assignment A"*
- `init` and

$$d_0(a) = \nu(V_{a,\texttt{init}}(A_0)) + h_0(a)$$

$$d_i(a) = \begin{cases} \nu(V_{a,\texttt{factor}}(A_i)) \times h_i(a) & \text{if } V_{a,\texttt{factor}}(A_i) \neq \emptyset \\ h_i(a) & \text{otherwise} \end{cases}$$

- `sign`

$$t_i(a) = \begin{cases} \boldsymbol{T} & \text{if } \nu(V_{a,\texttt{sign}}(A_i)) > 0 \\ \boldsymbol{F} & \text{if } \nu(V_{a,\texttt{sign}}(A_i)) < 0 \\ s_i(a) & \text{otherwise} \end{cases}$$

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Selected high scores from systematic experiments

Setting	*Labyrinth*	*Sokoban*	*Hanoi Tower*
base configuration	9,108*s* (14) 24,545,667	2,844*s* (3) 19,371,267	9,137*s* (11) 41,016,235
a, `init`, 2	95% (12) 94%	91% (1) 84%	85% (9) 89%
a, `factor`, 4	78% (8) 30%	120% (1) 107%	109% (11) 110%
a, `factor`, 16	78% (10) 23%	120% (1) 107%	109% (11) 110%
a, `level`, 1	90% (12) 5%	119% (2) 91%	126% (15) 120%
f, `init`, 2	103% (14) 123%	74% (2) 71%	97% (10) 109%
f, `factor`, 2	98% (12) 49%	116% (3) 134%	55% (6) 70%
f, `sign`, `-1`	94% (13) 89%	105% (1) 100%	92% (12) 92%

base configuration versus 38 (static) heuristic modifications (action, a, and fluent, f)

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Abductive problems with optimization

Setting	*Diagnosis*	*Expansion*	*Repair (H)*	*Repair (S)*
base configuration	111.1*s* (115)	161.5*s* (100)	101.3*s* (113)	33.3*s* (27)
`sign,-1`	324.5*s* (407)	7.6*s* (3)	8.4*s* (5)	3.1*s* (0)
`sign,-1 factor,2`	310.1*s* (387)	7.4*s* (2)	3.5*s* (0)	3.2*s* (1)
`sign,-1 factor,8`	305.9*s* (376)	7.7*s* (2)	3.1*s* (0)	2.9*s* (0)
`sign,-1 level,1`	76.1*s* (83)	6.6*s* (2)	0.8*s* (0)	2.2*s* (1)
`level,1`	77.3*s* (86)	12.9*s* (5)	3.4*s* (0)	2.1*s* (0)

(abducibles subject to optimization)

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(abducibles subject to optimization)

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Planning Competition Benchmarks

```
_heuristic(holds(F,T-1),true, t-T+1) :- holds(F,T).
_heuristic(holds(F,T-1),false,t-T+1) :-
                  fluent(F), time(T), not holds(F,T).
```

Problem	*base configuration*		_heuristic		*base c. (SAT)*		_heur. *(SAT)*	
Blocks'00	134.4*s*	(180/61)	9.2*s*	(239/3)	163.2*s*	(59)	2.6*s*	(0)
Elevator'00	3.1*s*	(279/0)	0.0*s*	(279/0)	3.4*s*	(0)	0.0*s*	(0)
Freecell'00	288.7*s*	(147/115)	184.2*s*	(194/74)	226.4*s*	(47)	52.0*s*	(0)
Logistics'00	145.8*s*	(148/61)	115.3*s*	(168/52)	113.9*s*	(23)	15.5*s*	(3)
Depots'02	400.3*s*	(51/184)	297.4*s*	(115/135)	389.0*s*	(64)	61.6*s*	(0)
Driverlog'02	308.3*s*	(108/143)	189.6*s*	(169/92)	245.8*s*	(61)	6.1*s*	(0)
Rovers'02	245.8*s*	(138/112)	165.7*s*	(179/79)	162.9*s*	(41)	5.7*s*	(0)
Satellite'02	398.4*s*	(73/186)	229.9*s*	(155/106)	364.6*s*	(82)	30.8*s*	(0)
Zenotravel'02	350.7*s*	(101/169)	239.0*s*	(154/116)	224.5*s*	(53)	6.3*s*	(0)
Total	252.8*s*	(1225/1031)	158.9*s*	(1652/657)	187.2*s*	(430)	17.1*s*	(3)

Potassco

Planning Competition Benchmarks

```
_heuristic(holds(F,T-1),true, t-T+1) :- holds(F,T).
_heuristic(holds(F,T-1),false,t-T+1) :-
                  fluent(F), time(T), not holds(F,T).
```

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Potassco

Outline

Potassco

Clingo species

Clingo = *gringo* | *clasp*

- Before
  - *Clingo* — easy solving
    iClingo — incremental solving
    oClingo — reactive solving
- After
  - *Clingo* — easy solving
    + incremental solving
    + reactive solving
    + complex solving
- *Clingo* series 4 = ASP + Control
- Multi-shot ASP solving deals with continously changing programs

Potassco

Clingo species

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Potassco

Outline

Potassco

Clingo series 4

- ASP
  - `#program <name> [ (<parameters>) ]`
    - Example `#program play(t).`
    - Default `#program base.`
  - `#external <atom> [ : <body> ]`
    - Example `#external mark(X,Y,P,t) : field(X,Y), player(P).`
  - Grounding yields a pair (P, E) of ground rules and ground atoms, whose semantics is captured by module theory
- Control
  - Lua
    - Example `prg:solve(), prg:ground(parts), ...`
  - Python
    - Example `prg.solve(), prg.ground(parts), ...`

  embedded scripting language (`#script`)
  libraries

Potassco

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Potassco

Vanilla *Clingo*

- Emulating *Clingo* in *Clingo* 4

```
#script (python)
def main(prg):
    parts = []
    parts.append(("base", []))
    prg.ground(parts)
    prg.solve()
#end.
```

Potassco

Vanilla *Clingo*

- Emulating *Clingo* in *Clingo* 4

```
#script (python)
def main(prg):
    parts = []
    parts.append(("base", []))
    prg.ground(parts)
    prg.solve()
#end.
```

Vanilla *Clingo*

- Emulating *Clingo* in *Clingo* 4

```
#script (python)
def main(prg):
    parts = []
    parts.append(("base", []))
    prg.ground(parts)
    prg.solve()
#end.
```

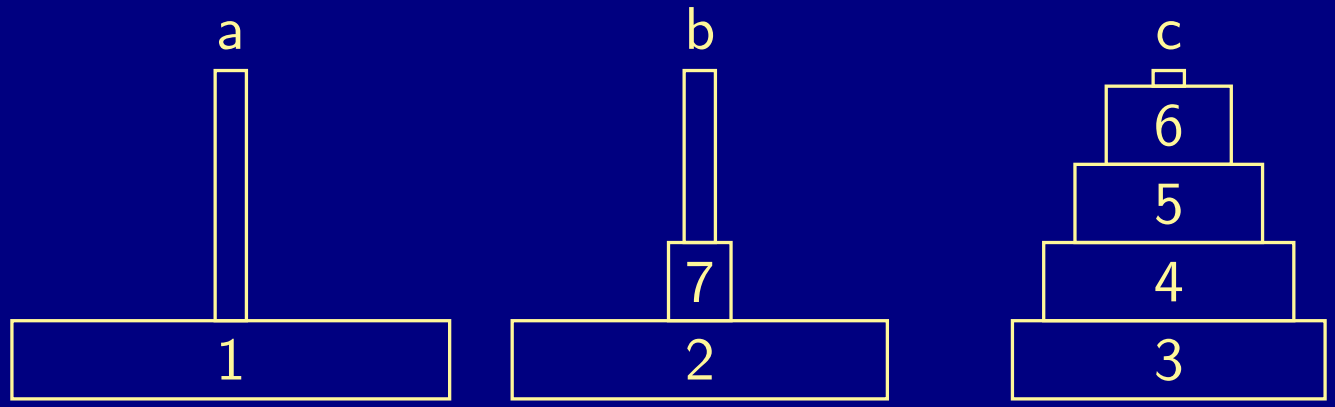
Outline

Potassco

Towers of Hanoi Instance

- Emulating *iClingo* in *Clingo* 4
  - Incremental grounding
  - Incremental solving

Towers of Hanoi Instance




```
peg(a;b;c).
init_on(1,a).
init_on((2;7),b).
init_on((3;4;5;6),c).

disk(1..7).

goal_on((3;4),a).
goal_on((1;2;5;6;7),c).
```

Potassco

Towers of Hanoi Encoding (base)

```
#program base.

on(D,P,0) :- init_on(D,P).
```

Towers of Hanoi Encoding (cumulative)

```
#program cumulative(t).

1 { move(D,P,t) : disk(D), peg(P) } 1.

moved(D,t) :- move(D,_,t).
blocked(D,P,t) :- on(D+1,P,t-1), disk(D).
blocked(D,P,t) :- blocked(D+1,P,t), disk(D).
:- move(D,P,t), blocked(D-1,P,t).
:- moved(D,t), on(D,P,t-1), blocked(D,P,t).

on(D,P,t) :- on(D,P,t-1), not moved(D,t).
on(D,P,t) :- move(D,P,t).
:- not 1 { on(D,P,t) : peg(P) } 1, disk(D).
```

Potassco

Towers of Hanoi Encoding (volatile)

```
#program volatile(t).

#external query(t).

:- goal_on(D,P), not on(D,P,t), query(t).
```

Incremental Solving (embedded)

```
#script (python)

from gringo import SolveResult, Fun

def main(prg):
    ret, parts, step = SolveResult.UNSAT, [], 1
    parts.append(("base", []))
    while ret == SolveResult.UNSAT:
        parts.append(("cumulative", [step]))
        parts.append(("volatile", [step]))
        prg.ground(parts)
        prg.release_external(Fun("query", [step-1]))
        prg.assign_external(Fun("query", [step]), True)
        ret, parts, step = prg.solve(), [], step+1

#end.
```

Potassco

Incremental Solving (library)

```
from sys import stdout
from gringo import SolveResult, Fun, Control

prg = Control()
prg.load("toh.lp")

ret, parts, step = SolveResult.UNSAT, [], 1
parts.append(("base", []))
while ret == SolveResult.UNSAT:
    parts.append(("cumulative", [step]))
    parts.append(("volatile", [step]))
    prg.ground(parts)
    prg.release_external(Fun("query", [step-1]))
    prg.assign_external(Fun("query", [step]), True)
    f = lambda m: stdout.write(str(m))
    ret, parts, step = prg.solve(on_model=f), [], step+1
```

Potassco

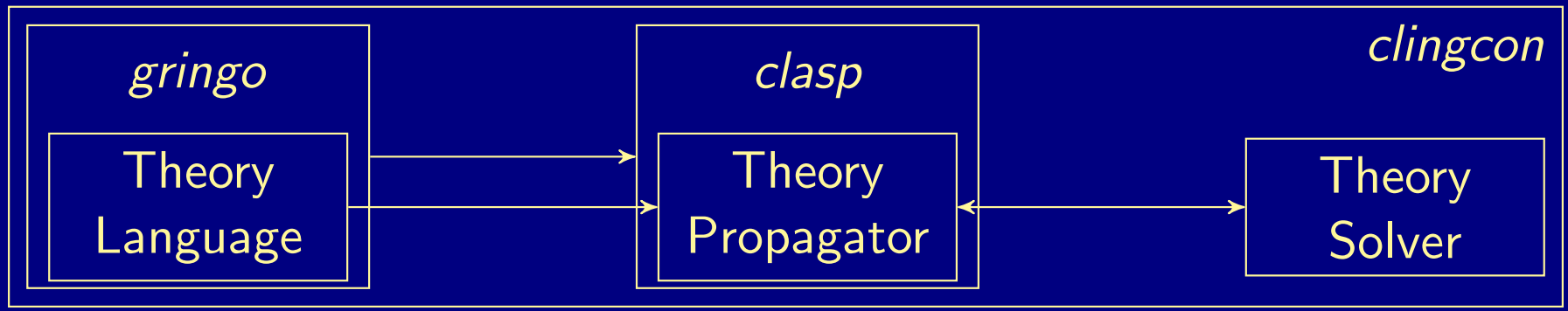
Outline

Potassco

clingcon

- Hybrid grounding and solving
- Solving in hybrid domains, like Bio-Informatics

- Basic architecture of *clingcon*:



Pouring Water into Buckets on a Scale

```
time(0..t).                 $domain(0..500).
bucket(a).                  volume(a,0) $== 0.
bucket(b).                  volume(b,0) $== 100.

1 { pour(B,T) : bucket(B) } 1 :- time(T), T < t.

          1 $<= amount(B,T) :- pour(B,T), T < t.
amount(B,T) $<= 30          :- pour(B,T), T < t.
amount(B,T) $==  0          :- not pour(B,T), bucket(B), time(T), T < t.

volume(B,T+1) $== volume(B,T) $+ amount(B,T) :- bucket(B), time(T), T < t.

down(B,T) :- volume(C,T) $< volume(B,T), bucket(B;C), time(T).
  up(B,T) :- not down(B,T), bucket(B), time(T).

 :- up(a,t).
```

Potassco

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 :- up(a,t).
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Pouring Water into Buckets on a Scale

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1 { pour(B,T) : bucket(B) } 1 :- time(T), T < t.

 :- pour(B,T), T < t, not (1 $<= amount(B,T)).
amount(B,T) $<= 30            :- pour(B,T), T < t.
amount(B,T) $==  0            :- not pour(B,T), bucket(B), time(T), T < t.

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 :- pour(B,T), T < t, 1 $> amount(B,T).
amount(B,T) $<= 30            :- pour(B,T), T < t.
amount(B,T) $==  0            :- not pour(B,T), bucket(B), time(T), T < t.

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 :- pour(B,T), T < t, 1 $> amount(B,T).
 :- pour(B,T), T < t, amount(B,T) $> 30.
 :- not pour(B,T), bucket(B), time(T), T < t, amount(B,T) $!=  0.

volume(B,T+1) $== volume(B,T) $+ amount(B,T) :- bucket(B), time(T), T < t.

down(B,T) :- volume(C,T) $< volume(B,T), bucket(B;C), time(T).
  up(B,T) :- not down(B,T), bucket(B), time(T).

 :- up(a,t).
```

Pouring Water into Buckets on a Scale

```
time(0..t).                 $domain(0..500).
bucket(a).                  volume(a,0) $== 0.
bucket(b).                  volume(b,0) $== 100.

1 { pour(B,T) : bucket(B) } 1 :- time(T), T < t.

 :- pour(B,T), T < t, 1 $> amount(B,T).
 :- pour(B,T), T < t, amount(B,T) $> 30.
 :- not pour(B,T), bucket(B), time(T), T < t, amount(B,T) $!=  0.

 :- bucket(B), time(T), T < t, volume(B,T+1) $!= volume(B,T)$+amount(B,T).

down(B,T) :- volume(C,T) $< volume(B,T), bucket(B;C), time(T).
  up(B,T) :- not down(B,T), bucket(B), time(T).

 :- up(a,t).
```

Potassco

Pouring Water into Buckets on a Scale

```
$ clingcon --const t=4 balance.lp --text
```

```
time(0). ... time(4).
bucket(a).
bucket(b).

1 { pour(b,0), pour(a,0) } 1.

 :- pour(a,0), 1 $> amount(a,0).
 :- pour(b,0), 1 $> amount(b,0).

 :- pour(a,0), amount(a,0) $> 30.
 :- pour(b,0), amount(b,0) $> 30.

 :- not pour(a,0), amount(a,0) $!= 0.
 :- not pour(b,0), amount(b,0) $!= 0.

 :- volume(a,1) $!= (volume(a,0) $+ amount(a,0)).
 :- volume(b,1) $!= (volume(b,0) $+ amount(b,0)).

down(a,0) :- volume(a,0) $< volume(a,0).
down(a,0) :- volume(b,0) $< volume(a,0).
down(b,0) :- volume(a,0) $< volume(b,0).
down(b,0) :- volume(b,0) $< volume(b,0).

up(a,0) :- not down(a,0).
up(b,0) :- not down(b,0).

 :- up(a,4).
```

```
$domain(0..500).
 :- volume(a,0) $!= 0.
 :- volume(b,0) $!= 100.

... 1 { pour(b,3), pour(a,3) } 1.

...  :- pour(a,3), 1 $> amount(a,3).
...  :- pour(b,3), 1 $> amount(b,3).

...  :- pour(a,3), amount(a,3) $> 30.
...  :- pour(b,3), amount(b,3) $> 30.

...  :- not pour(a,3), amount(a,3) $!= 0.
...  :- not pour(b,3), amount(b,3) $!= 0.

...  :- volume(a,4) $!= (volume(a,3) $+ amount(a,3)).
...  :- volume(b,4) $!= (volume(b,3) $+ amount(b,3)).

... down(a,4) :- volume(a,4) $< volume(a,4).
... down(a,4) :- volume(b,4) $< volume(a,4).
... down(b,4) :- volume(a,4) $< volume(b,4).
... down(b,4) :- volume(b,4) $< volume(b,4).

... up(a,4) :- not down(a,4).
... up(b,4) :- not down(b,4).
```

Potassco

Pouring Water into Buckets on a Scale

```
$ clingcon --const t=4 balance.lp --text
```

```
time(0). ... time(4).
bucket(a).
bucket(b).

1 { pour(b,0), pour(a,0) } 1.

 :- pour(a,0), 1 $> amount(a,0).
 :- pour(b,0), 1 $> amount(b,0).

 :- pour(a,0), amount(a,0) $> 30.
 :- pour(b,0), amount(b,0) $> 30.

 :- not pour(a,0), amount(a,0) $!= 0.
 :- not pour(b,0), amount(b,0) $!= 0.

 :- volume(a,1) $!= (volume(a,0) $+ amount(a,0)).
 :- volume(b,1) $!= (volume(b,0) $+ amount(b,0)).

down(a,0) :- volume(a,0) $< volume(a,0).
down(a,0) :- volume(b,0) $< volume(a,0).
down(b,0) :- volume(a,0) $< volume(b,0).
down(b,0) :- volume(b,0) $< volume(b,0).

up(a,0) :- not down(a,0).
up(b,0) :- not down(b,0).

 :- up(a,4).
```

```
$domain(0..500).
 :- volume(a,0) $!= 0.
 :- volume(b,0) $!= 100.

... 1 { pour(b,3), pour(a,3) } 1.

...  :- pour(a,3), 1 $> amount(a,3).
...  :- pour(b,3), 1 $> amount(b,3).

...  :- pour(a,3), amount(a,3) $> 30.
...  :- pour(b,3), amount(b,3) $> 30.

...  :- not pour(a,3), amount(a,3) $!= 0.
...  :- not pour(b,3), amount(b,3) $!= 0.

...  :- volume(a,4) $!= (volume(a,3) $+ amount(a,3)).
...  :- volume(b,4) $!= (volume(b,3) $+ amount(b,3)).

... down(a,4) :- volume(a,4) $< volume(a,4).
... down(a,4) :- volume(b,4) $< volume(a,4).
... down(b,4) :- volume(a,4) $< volume(b,4).
... down(b,4) :- volume(b,4) $< volume(b,4).

... up(a,4) :- not down(a,4).
... up(b,4) :- not down(b,4).
```

Potassco

Pouring Water into Buckets on a Scale

```
$ clingcon --const t=4 balance.lp --text
```

```
time(0). ... time(4).
bucket(a).
bucket(b).

1 { pour(b,0), pour(a,0) } 1.

 :- pour(a,0), 1 $> amount(a,0).
 :- pour(b,0), 1 $> amount(b,0).

 :- pour(a,0), amount(a,0) $> 30.
 :- pour(b,0), amount(b,0) $> 30.

 :- not pour(a,0), amount(a,0) $!= 0.
 :- not pour(b,0), amount(b,0) $!= 0.

 :- volume(a,1) $!= (volume(a,0) $+ amount(a,0)).
 :- volume(b,1) $!= (volume(b,0) $+ amount(b,0)).

down(a,0) :- volume(a,0) $< volume(a,0).
down(a,0) :- volume(b,0) $< volume(a,0).
down(b,0) :- volume(a,0) $< volume(b,0).
down(b,0) :- volume(b,0) $< volume(b,0).

up(a,0) :- not down(a,0).
up(b,0) :- not down(b,0).

 :- up(a,4).
```

```
$domain(0..500).
 :- volume(a,0) $!= 0.
 :- volume(b,0) $!= 100.

... 1 { pour(b,3), pour(a,3) } 1.

...  :- pour(a,3), 1 $> amount(a,3).
...  :- pour(b,3), 1 $> amount(b,3).

...  :- pour(a,3), amount(a,3) $> 30.
...  :- pour(b,3), amount(b,3) $> 30.

...  :- not pour(a,3), amount(a,3) $!= 0.
...  :- not pour(b,3), amount(b,3) $!= 0.

...  :- volume(a,4) $!= (volume(a,3) $+ amount(a,3)).
...  :- volume(b,4) $!= (volume(b,3) $+ amount(b,3)).

... down(a,4) :- volume(a,4) $< volume(a,4).
... down(a,4) :- volume(b,4) $< volume(a,4).
... down(b,4) :- volume(a,4) $< volume(b,4).
... down(b,4) :- volume(b,4) $< volume(b,4).

... up(a,4) :- not down(a,4).
... up(b,4) :- not down(b,4).
```

Potassco

Pouring Water into Buckets on a Scale

```
$ clingcon --const t=4 balance.lp --text
```

```
time(0). ... time(4).
bucket(a).
bucket(b).

1 { pour(b,0), pour(a,0) } 1.

 :- pour(a,0), 1 $> amount(a,0).
 :- pour(b,0), 1 $> amount(b,0).

 :- pour(a,0), amount(a,0) $> 30.
 :- pour(b,0), amount(b,0) $> 30.

 :- not pour(a,0), amount(a,0) $!= 0.
 :- not pour(b,0), amount(b,0) $!= 0.

 :- volume(a,1) $!= (volume(a,0) $+ amount(a,0)).
 :- volume(b,1) $!= (volume(b,0) $+ amount(b,0)).

down(a,0) :- volume(a,0) $< volume(a,0).
down(a,0) :- volume(b,0) $< volume(a,0).
down(b,0) :- volume(a,0) $< volume(b,0).
down(b,0) :- volume(b,0) $< volume(b,0).

up(a,0) :- not down(a,0).
up(b,0) :- not down(b,0).

 :- up(a,4).
```

```
$domain(0..500).
 :- volume(a,0) $!= 0.
 :- volume(b,0) $!= 100.

... 1 { pour(b,3), pour(a,3) } 1.

...  :- pour(a,3), 1 $> amount(a,3).
...  :- pour(b,3), 1 $> amount(b,3).

...  :- pour(a,3), amount(a,3) $> 30.
...  :- pour(b,3), amount(b,3) $> 30.

...  :- not pour(a,3), amount(a,3) $!= 0.
...  :- not pour(b,3), amount(b,3) $!= 0.

...  :- volume(a,4) $!= (volume(a,3) $+ amount(a,3)).
...  :- volume(b,4) $!= (volume(b,3) $+ amount(b,3)).

... down(a,4) :- volume(a,4) $< volume(a,4).
... down(a,4) :- volume(b,4) $< volume(a,4).
... down(b,4) :- volume(a,4) $< volume(b,4).
... down(b,4) :- volume(b,4) $< volume(b,4).

... up(a,4) :- not down(a,4).
... up(b,4) :- not down(b,4).
```

Potassco

Pouring Water into Buckets on a Scale

```
$ clingcon --const t=4 balance.lp --text
```

```
time(0). ... time(4).
bucket(a).
bucket(b).

1 { pour(b,0), pour(a,0) } 1.

 :- pour(a,0), 1 $> amount(a,0).
 :- pour(b,0), 1 $> amount(b,0).

 :- pour(a,0), amount(a,0) $> 30.
 :- pour(b,0), amount(b,0) $> 30.

 :- not pour(a,0), amount(a,0) $!= 0.
 :- not pour(b,0), amount(b,0) $!= 0.

 :- volume(a,1) $!= (volume(a,0) $+ amount(a,0)).
 :- volume(b,1) $!= (volume(b,0) $+ amount(b,0)).

down(a,0) :- volume(a,0) $< volume(a,0).
down(a,0) :- volume(b,0) $< volume(a,0).
down(b,0) :- volume(a,0) $< volume(b,0).
down(b,0) :- volume(b,0) $< volume(b,0).

up(a,0) :- not down(a,0).
up(b,0) :- not down(b,0).

 :- up(a,4).
```

```
$domain(0..500).
 :- volume(a,0) $!= 0.
 :- volume(b,0) $!= 100.

... 1 { pour(b,3), pour(a,3) } 1.

...  :- pour(a,3), 1 $> amount(a,3).
...  :- pour(b,3), 1 $> amount(b,3).

...  :- pour(a,3), amount(a,3) $> 30.
...  :- pour(b,3), amount(b,3) $> 30.

...  :- not pour(a,3), amount(a,3) $!= 0.
...  :- not pour(b,3), amount(b,3) $!= 0.

...  :- volume(a,4) $!= (volume(a,3) $+ amount(a,3)).
...  :- volume(b,4) $!= (volume(b,3) $+ amount(b,3)).

... down(a,4) :- volume(a,4) $< volume(a,4).
... down(a,4) :- volume(b,4) $< volume(a,4).
... down(b,4) :- volume(a,4) $< volume(b,4).
... down(b,4) :- volume(b,4) $< volume(b,4).

... up(a,4) :- not down(a,4).
... up(b,4) :- not down(b,4).
```

Potassco

Pouring Water into Buckets on a Scale

```
$ clingcon --const t=4 balance.lp 0

Answer: 1
pour(a,0)   pour(a,1)   pour(a,2)   pour(a,3)

amount(a,0)=[11..30]   amount(b,0)=0          1 $> amount(b,0)   amount(a,0) $!= 0
amount(a,1)=[11..30]   amount(b,1)=0          1 $> amount(b,1)   amount(a,1) $!= 0
amount(a,2)=[11..30]   amount(b,2)=0          1 $> amount(b,2)   amount(a,2) $!= 0
amount(a,3)=[11..30]   amount(b,3)=0          1 $> amount(b,3)   amount(a,3) $!= 0

volume(a,0)=0          volume(b,0)=100      volume(a,0) $< volume(b,0)
volume(a,1)=[11..30]   volume(b,1)=100      volume(a,1) $< volume(b,1)
volume(a,2)=[41..60]   volume(b,2)=100      volume(a,2) $< volume(b,2)
volume(a,3)=[71..90]   volume(b,3)=100      volume(a,3) $< volume(b,3)
volume(a,4)=[101..120] volume(b,4)=100      volume(b,4) $< volume(a,4)

SATISFIABLE

Models       : 1
Time         : 0.000
```

Potassco

Pouring Water into Buckets on a Scale

```
$ clingcon --const t=4 balance.lp 0

Answer: 1
pour(a,0)   pour(a,1)   pour(a,2)   pour(a,3)

amount(a,0)=[11..30]   amount(b,0)=0          1 $> amount(b,0)   amount(a,0) $!= 0
amount(a,1)=[11..30]   amount(b,1)=0          1 $> amount(b,1)   amount(a,1) $!= 0
amount(a,2)=[11..30]   amount(b,2)=0          1 $> amount(b,2)   amount(a,2) $!= 0
amount(a,3)=[11..30]   amount(b,3)=0          1 $> amount(b,3)   amount(a,3) $!= 0

volume(a,0)=0          volume(b,0)=100      volume(a,0) $< volume(b,0)
volume(a,1)=[11..30]   volume(b,1)=100      volume(a,1) $< volume(b,1)
volume(a,2)=[41..60]   volume(b,2)=100      volume(a,2) $< volume(b,2)
volume(a,3)=[71..90]   volume(b,3)=100      volume(a,3) $< volume(b,3)
volume(a,4)=[101..120] volume(b,4)=100      volume(b,4) $< volume(a,4)

SATISFIABLE

Models       : 1
Time         : 0.000
```

Potassco

Pouring Water into Buckets on a Scale

```
$ clingcon --const t=4 balance.lp 0

Answer: 1
pour(a,0)   pour(a,1)   pour(a,2)   pour(a,3)

amount(a,0)=[11..30]   amount(b,0)=0          1 $> amount(b,0)   amount(a,0) $!= 0
amount(a,1)=[11..30]   amount(b,1)=0          1 $> amount(b,1)   amount(a,1) $!= 0
amount(a,2)=[11..30]   amount(b,2)=0          1 $> amount(b,2)   amount(a,2) $!= 0
amount(a,3)=[11..30]   amount(b,3)=0          1 $> amount(b,3)   amount(a,3) $!= 0

volume(a,0)=0          volume(b,0)=100      volume(a,0) $< volume(b,0)
volume(a,1)=[11..30]   volume(b,1)=100      volume(a,1) $< volume(b,1)
volume(a,2)=[41..60]   volume(b,2)=100      volume(a,2) $< volume(b,2)
volume(a,3)=[71..90]   volume(b,3)=100      volume(a,3) $< volume(b,3)
volume(a,4)=[101..120] volume(b,4)=100      volume(b,4) $< volume(a,4)

SATISFIABLE

Models       : 1
Time         : 0.000
```

Potassco

Pouring Water into Buckets on a Scale

```
$ clingcon --const t=4 balance.lp 0

Answer: 1
pour(a,0)   pour(a,1)   pour(a,2)   pour(a,3)

amount(a,0)=[11..30]   amount(b,0)=0          1 $> amount(b,0)   amount(a,0) $!= 0
amount(a,1)=[11..30]   amount(b,1)=0          1 $> amount(b,1)   amount(a,1) $!= 0
amount(a,2)=[11..30]   amount(b,2)=0          1 $> amount(b,2)   amount(a,2) $!= 0
amount(a,3)=[11..30]   amount(b,3)=0          1 $> amount(b,3)   amount(a,3) $!= 0

volume(a,0)=0          volume(b,0)=100      volume(a,0) $< volume(b,0)
volume(a,1)=[11..30]   volume(b,1)=100      volume(a,1) $< volume(b,1)
volume(a,2)=[41..60]   volume(b,2)=100      volume(a,2) $< volume(b,2)
volume(a,3)=[71..90]   volume(b,3)=100      volume(a,3) $< volume(b,3)
volume(a,4)=[101..120] volume(b,4)=100      volume(b,4) $< volume(a,4)

SATISFIABLE

Models       : 1
Time         : 0.000
```

Potassco

Pouring Water into Buckets on a Scale

```
$ clingcon --const t=4 balance.lp 0

Answer: 1
pour(a,0)   pour(a,1)   pour(a,2)   pour(a,3)

amount(a,0)=[11..30]   amount(b,0)=0          1 $> amount(b,0)   amount(a,0) $!= 0
amount(a,1)=[11..30]   amount(b,1)=0          1 $> amount(b,1)   amount(a,1) $!= 0
amount(a,2)=[11..30]   amount(b,2)=0          1 $> amount(b,2)   amount(a,2) $!= 0
amount(a,3)=[11..30]   amount(b,3)=0          1 $> amount(b,3)   amount(a,3) $!= 0

volume(a,0)=0          volume(b,0)=100     volume(a,0) $< volume(b,0)
volume(a,1)=[11..30]   volume(b,1)=100     volume(a,1) $< volume(b,1)
volume(a,2)=[41..60]   volume(b,2)=100     volume(a,2) $< volume(b,2)
volume(a,3)=[71..90]   volume(b,3)=100     volume(a,3) $< volume(b,3)
volume(a,4)=[101..120] volume(b,4)=100     volume(b,4) $< volume(a,4)

SATISFIABLE

Models       : 1
Time         : 0.000
```

Boolean variables

Pouring Water into Buckets on a Scale

```
$ clingcon --const t=4 balance.lp 0

Answer: 1
pour(a,0)   pour(a,1)   pour(a,2)   pour(a,3)

amount(a,0)=[11..30]   amount(b,0)=0          1 $> amount(b,0)   amount(a,0) $!= 0
amount(a,1)=[11..30]   amount(b,1)=0          1 $> amount(b,1)   amount(a,1) $!= 0
amount(a,2)=[11..30]   amount(b,2)=0          1 $> amount(b,2)   amount(a,2) $!= 0
amount(a,3)=[11..30]   amount(b,3)=0          1 $> amount(b,3)   amount(a,3) $!= 0

volume(a,0)=0          volume(b,0)=100     volume(a,0) $< volume(b,0)
volume(a,1)=[11..30]   volume(b,1)=100     volume(a,1) $< volume(b,1)
volume(a,2)=[41..60]   volume(b,2)=100     volume(a,2) $< volume(b,2)
volume(a,3)=[71..90]   volume(b,3)=100     volume(a,3) $< volume(b,3)
volume(a,4)=[101..120] volume(b,4)=100     volume(b,4) $< volume(a,4)

SATISFIABLE

Models       : 1
Time         : 0.000
```

Non-Boolean variables

Pouring Water into Buckets on a Scale

```
$ clingcon --const t=4 balance.lp --csp-num-as=1

Answer: 1
pour(a,0)   pour(a,1)   pour(a,2)   pour(a,3)

amount(a,0)=11          amount(b,0)=0          1 $> amount(b,0)   amount(a,0) $!= 0
amount(a,1)=30          amount(b,1)=0          1 $> amount(b,1)   amount(a,1) $!= 0
amount(a,2)=30          amount(b,2)=0          1 $> amount(b,2)   amount(a,2) $!= 0
amount(a,3)=30          amount(b,3)=0          1 $> amount(b,3)   amount(a,3) $!= 0

volume(a,0)=0           volume(b,0)=100        volume(a,0) $< volume(b,0)
volume(a,1)=11          volume(b,1)=100        volume(a,1) $< volume(b,1)
volume(a,2)=41          volume(b,2)=100        volume(a,2) $< volume(b,2)
volume(a,3)=71          volume(b,3)=100        volume(a,3) $< volume(b,3)
volume(a,4)=101         volume(b,4)=100        volume(b,4) $< volume(a,4)

SATISFIABLE

Models       : 1+
Time         : 0.000
```

Potassco

Pouring Water into Buckets on a Scale

```
$ clingcon --const t=4 balance.lp --csp-num-as=1

Answer: 1
pour(a,0)   pour(a,1)   pour(a,2)   pour(a,3)

amount(a,0)=11          amount(b,0)=0          1 $> amount(b,0)   amount(a,0) $!= 0
amount(a,1)=30          amount(b,1)=0          1 $> amount(b,1)   amount(a,1) $!= 0
amount(a,2)=30          amount(b,2)=0          1 $> amount(b,2)   amount(a,2) $!= 0
amount(a,3)=30          amount(b,3)=0          1 $> amount(b,3)   amount(a,3) $!= 0

volume(a,0)=0           volume(b,0)=100        volume(a,0) $< volume(b,0)
volume(a,1)=11          volume(b,1)=100        volume(a,1) $< volume(b,1)
volume(a,2)=41          volume(b,2)=100        volume(a,2) $< volume(b,2)
volume(a,3)=71          volume(b,3)=100        volume(a,3) $< volume(b,3)
volume(a,4)=101         volume(b,4)=100        volume(b,4) $< volume(a,4)

SATISFIABLE

Models       : 1+
Time         : 0.000
```

Potassco

Pouring Water into Buckets on a Scale

```
$ clingcon --const t=4 balance.lp --csp-num-as=1

Answer: 1
pour(a,0)   pour(a,1)   pour(a,2)   pour(a,3)

amount(a,0)=11          amount(b,0)=0          1 $> amount(b,0)   amount(a,0) $!= 0
amount(a,1)=30          amount(b,1)=0          1 $> amount(b,1)   amount(a,1) $!= 0
amount(a,2)=30          amount(b,2)=0          1 $> amount(b,2)   amount(a,2) $!= 0
amount(a,3)=30          amount(b,3)=0          1 $> amount(b,3)   amount(a,3) $!= 0

volume(a,0)=0           volume(b,0)=100        volume(a,0) $< volume(b,0)
volume(a,1)=11          volume(b,1)=100        volume(a,1) $< volume(b,1)
volume(a,2)=41          volume(b,2)=100        volume(a,2) $< volume(b,2)
volume(a,3)=71          volume(b,3)=100        volume(a,3) $< volume(b,3)
volume(a,4)=101         volume(b,4)=100        volume(b,4) $< volume(a,4)

SATISFIABLE

Models       : 1+
Time         : 0.000
```

Potassco

Pouring Water into Buckets on a Scale

```
$ clingcon --const t=4 balance.lp --csp-num-as=1

Answer: 1
pour(a,0)   pour(a,1)   pour(a,2)   pour(a,3)

amount(a,0)=11          amount(b,0)=0          1 $> amount(b,0)   amount(a,0) $!= 0
amount(a,1)=30          amount(b,1)=0          1 $> amount(b,1)   amount(a,1) $!= 0
amount(a,2)=30          amount(b,2)=0          1 $> amount(b,2)   amount(a,2) $!= 0
amount(a,3)=30          amount(b,3)=0          1 $> amount(b,3)   amount(a,3) $!= 0

volume(a,0)=0           volume(b,0)=100        volume(a,0) $< volume(b,0)
volume(a,1)=11          volume(b,1)=100        volume(a,1) $< volume(b,1)
volume(a,2)=41          volume(b,2)=100        volume(a,2) $< volume(b,2)
volume(a,3)=71          volume(b,3)=100        volume(a,3) $< volume(b,3)
volume(a,4)=101         volume(b,4)=100        volume(b,4) $< volume(a,4)

SATISFIABLE

Models       : 1+
Time         : 0.000
```

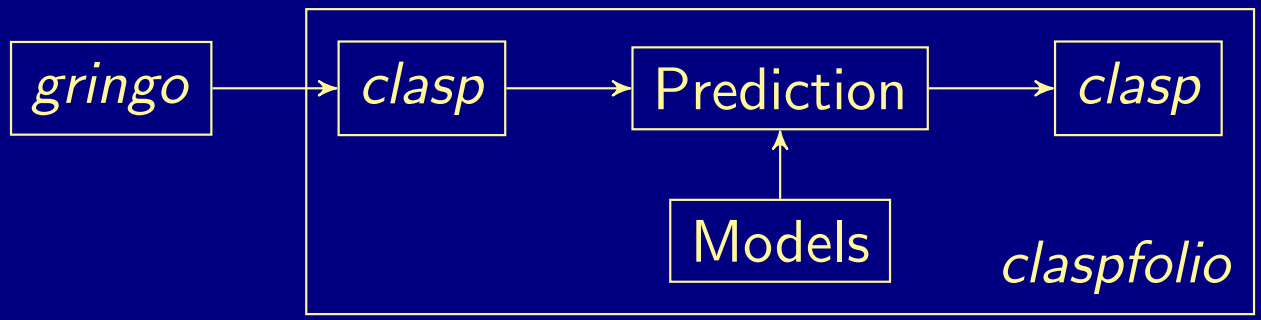
Potassco

Outline

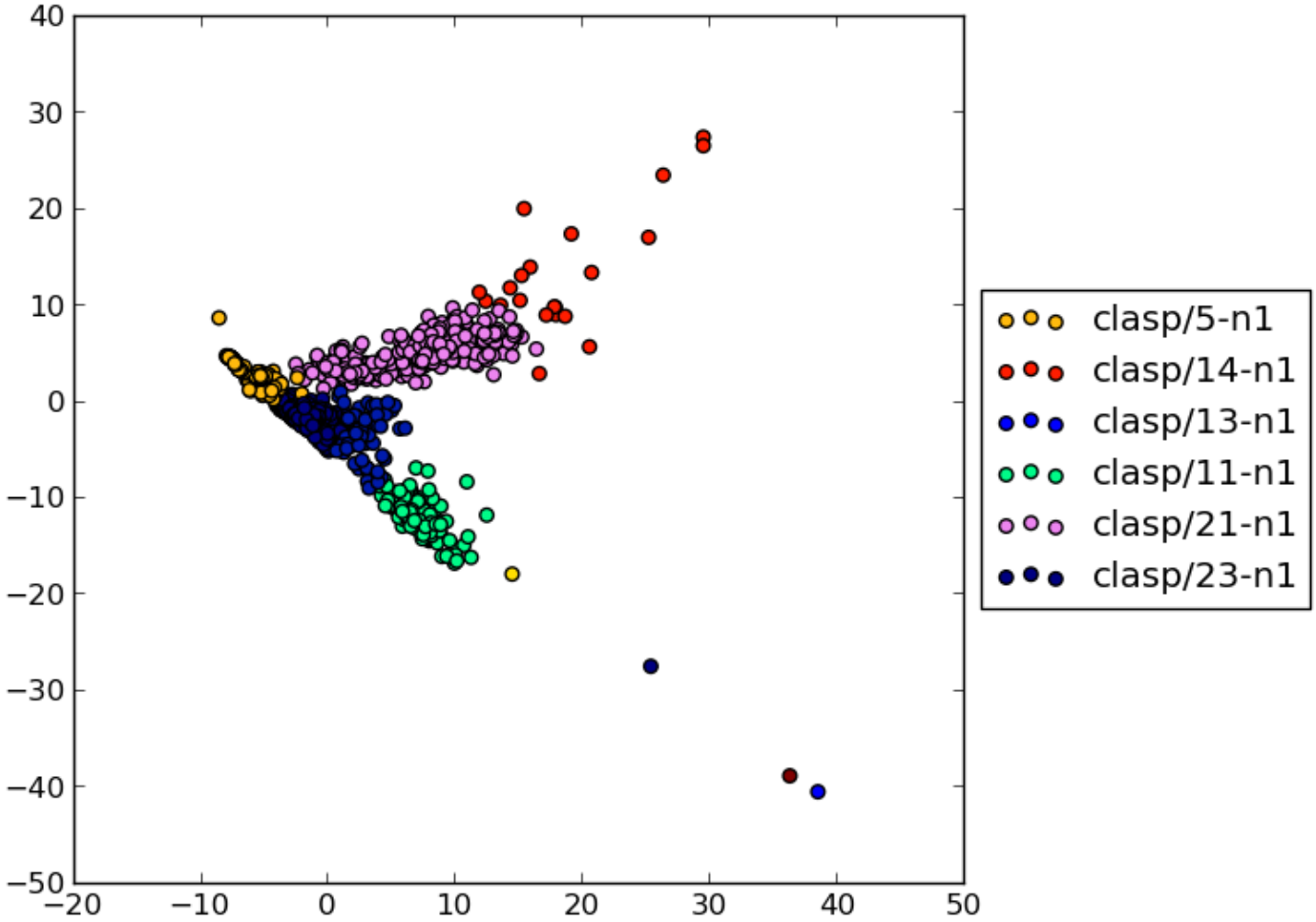
Potassco

claspfolio

- Automatic selection of some *clasp* configuration among several predefined ones via (learned) classifiers
- Basic architecture of *claspfolio*:



Instance Feature Clusters (after PCA)



Potassco

Solving with *clasp* (as usual)

```
$ clasp queens500 --quiet

clasp version 2.0.2
Reading from queens500
Solving...
SATISFIABLE

Models       : 1+
Time         : 11.445s (Solving: 10.58s 1st Model: 10.55s Unsat: 0.00s)
CPU Time     : 11.410s
```

Potassco

Solving with *clasp* (as usual)

```
$ clasp queens500 --quiet

clasp version 2.0.2
Reading from queens500
Solving...
SATISFIABLE

Models       : 1+
Time         : 11.445s (Solving: 10.58s 1st Model: 10.55s Unsat: 0.00s)
CPU Time     : 11.410s
```

Potassco

Solving with *claspfolio*

```
$ claspfolio queens500 --quiet

PRESOLVING
Reading from queens500
Solving...
claspfolio version 1.0.1 (based on clasp version 2.0.2)
Reading from queens500
Solving...
SATISFIABLE

Models       : 1+
Time         : 4.785s (Solving: 3.96s 1st Model: 3.92s Unsat: 0.00s)
CPU Time     : 4.780s
```

Potassco

Solving with *claspfolio*

```
$ claspfolio queens500 --quiet

PRESOLVING
Reading from queens500
Solving...
claspfolio version 1.0.1 (based on clasp version 2.0.2)
Reading from queens500
Solving...
SATISFIABLE

Models       : 1+
Time         : 4.785s (Solving: 3.96s 1st Model: 3.92s Unsat: 0.00s)
CPU Time     : 4.780s
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Potassco

Solving with *claspfolio*

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PRESOLVING
Reading from queens500
Solving...
claspfolio version 1.0.1 (based on clasp version 2.0.2)
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Solving with *claspfolio*

```
$ claspfolio queens500 --quiet

PRESOLVING
Reading from queens500
Solving...
claspfolio version 1.0.1 (based on clasp version 2.0.2)
Reading from queens500
Solving...
SATISFIABLE

Models       : 1+
Time         : 4.785s (Solving: 3.96s 1st Model: 3.92s Unsat: 0.00s)
CPU Time     : 4.780s
```

Potassco

Feature-extraction with *claspfolio*

```
$ claspfolio --features queens500

PRESOLVING
Reading from queens500
Solving...
UNKNOWN
Features    : 84998,3994,0,250000,1.020,62.594,63.844,21.281,84998, \
 3994,100,250000,1.020,62.594,63.844,21.281,84998,3994,250,250000,  \
 1.020,62.594,63.844,21.281,84998,3994,475,250000,1.020,62.594,     \
 63.844,21.281,757989,757989,0,510983,506992,3990,1,0,127.066,9983, \
 1023958,502993,1994,518971,1,0,0,254994,0,3990,0.100,0.000,99.900, \
 0,270303,812,4,0,812,2223,2223,262,262,2.738,2.738,0.000,812,812,  \
 2270.982,0,0.000

$ claspfolio --list-features

maxLearnt,Constraints,LearntConstraints,FreeVars,Vars/FreeVars, ...
```

Potassco

Feature-extraction with *claspfolio*

```
$ claspfolio --features queens500

PRESOLVING
Reading from queens500
Solving...
UNKNOWN
Features    : 84998,3994,0,250000,1.020,62.594,63.844,21.281,84998, \
 3994,100,250000,1.020,62.594,63.844,21.281,84998,3994,250,250000,  \
 1.020,62.594,63.844,21.281,84998,3994,475,250000,1.020,62.594,     \
 63.844,21.281,757989,757989,0,510983,506992,3990,1,0,127.066,9983, \
 1023958,502993,1994,518971,1,0,0,254994,0,3990,0.100,0.000,99.900, \
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 2270.982,0,0.000

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maxLearnt,Constraints,LearntConstraints,FreeVars,Vars/FreeVars, ...
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Potassco

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Reading from queens500
Solving...
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Features    : 84998,3994,0,250000,1.020,62.594,63.844,21.281,84998, \
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 1.020,62.594,63.844,21.281,84998,3994,475,250000,1.020,62.594,     \
 63.844,21.281,757989,757989,0,510983,506992,3990,1,0,127.066,9983, \
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 2270.982,0,0.000

$ claspfolio --list-features

maxLearnt,Constraints,LearntConstraints,FreeVars,Vars/FreeVars, ...
```

Potassco

Prediction with *claspfolio*

```
$ claspfolio queens500 --decisionvalues

PRESOLVING
Reading from queens500
Solving...

Portfolio Decision Values:
[1] : 3.437538   [10] : 3.639444   [19] : 3.726391
[2] : 3.501728   [11] : 3.483334   [20] : 3.020325
[3] : 3.784733   [12] : 3.271890   [21] : 3.220219
[4] : 3.672955   [13] : 3.344085   [22] : 3.998709
[5] : 3.557408   [14] : 3.315235   [23] : 3.961214
[6] : 3.942037   [15] : 3.620479   [24] : 3.512924
[7] : 3.335304   [16] : 3.396838   [25] : 3.078143
[8] : 3.375315   [17] : 3.238764
[9] : 3.432931   [18] : 3.403484

UNKNOWN
```

Potassco

Prediction with *claspfolio*

```
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Solving...

Portfolio Decision Values:
[1] : 3.437538   [10] : 3.639444   [19] : 3.726391
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[8] : 3.375315   [17] : 3.238764
[9] : 3.432931   [18] : 3.403484

UNKNOWN
```

Potassco

Solving with *claspfolio* (slightly verbosely)

```
$ claspfolio queens500 --quiet --autoverbose=1

PRESOLVING
Reading from queens500
Solving...

Chosen configuration: [20]
clasp --configurations=./models/portfolio.txt           \
      --modelpath=./models/                             \
      queens500 --quiet --autoverbose=1                 \
      --heu=VSIDS --sat-pre=20,25,120 --trans-ext=integ

claspfolio version 1.0.1 (based on clasp version 2.0.2)
Reading from queens500
Solving...
SATISFIABLE

Models       : 1+
Time         : 4.783s (Solving: 3.96s 1st Model: 3.93s Unsat: 0.00s)
CPU Time     : 4.760s
```

Potassco

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CPU Time     : 4.760s
```

Potassco

Outline

Potassco

clavis

- Analysis and visualization toolchain for clasp
- *clavis*
  - Event logger integrated in clasp
  - Records CDCL events like propagation, conflicts, restarts, ...
  - Generated logfiles readable with different backends
  - Easily configurable
  - Applicable to clasp variants like hclasp
- *insight*
  - Visualization backend for clavis
  - Combines information about problem structure and solving process
  - Networks for structural and aggregated information
  - Plots for temporal information and navigation

Potassco

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Potassco

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- *insight*
  - Visualization backend for clavis
  - Combines information about problem structure and solving process
  - Networks for structural and aggregated information
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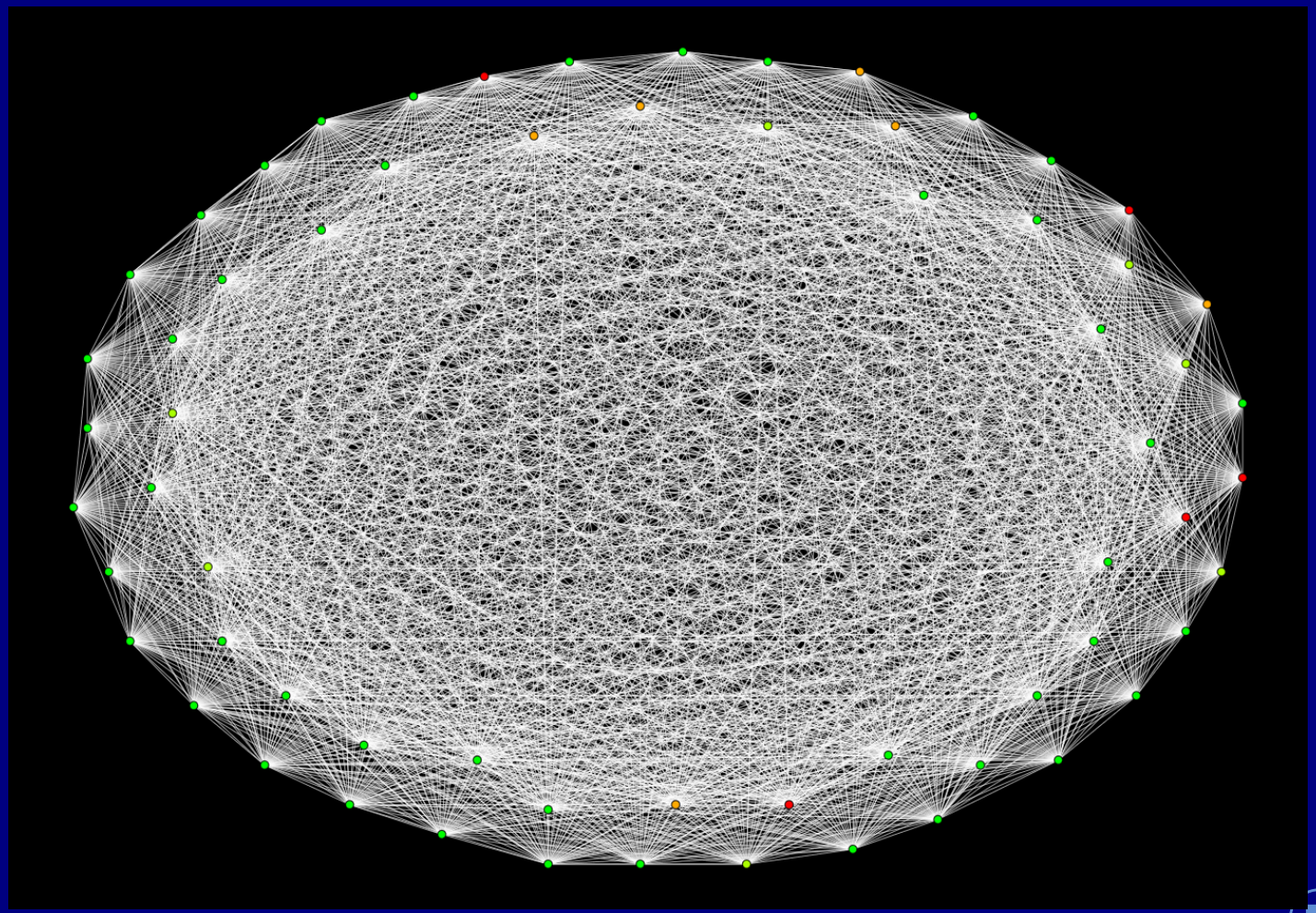
Potassco

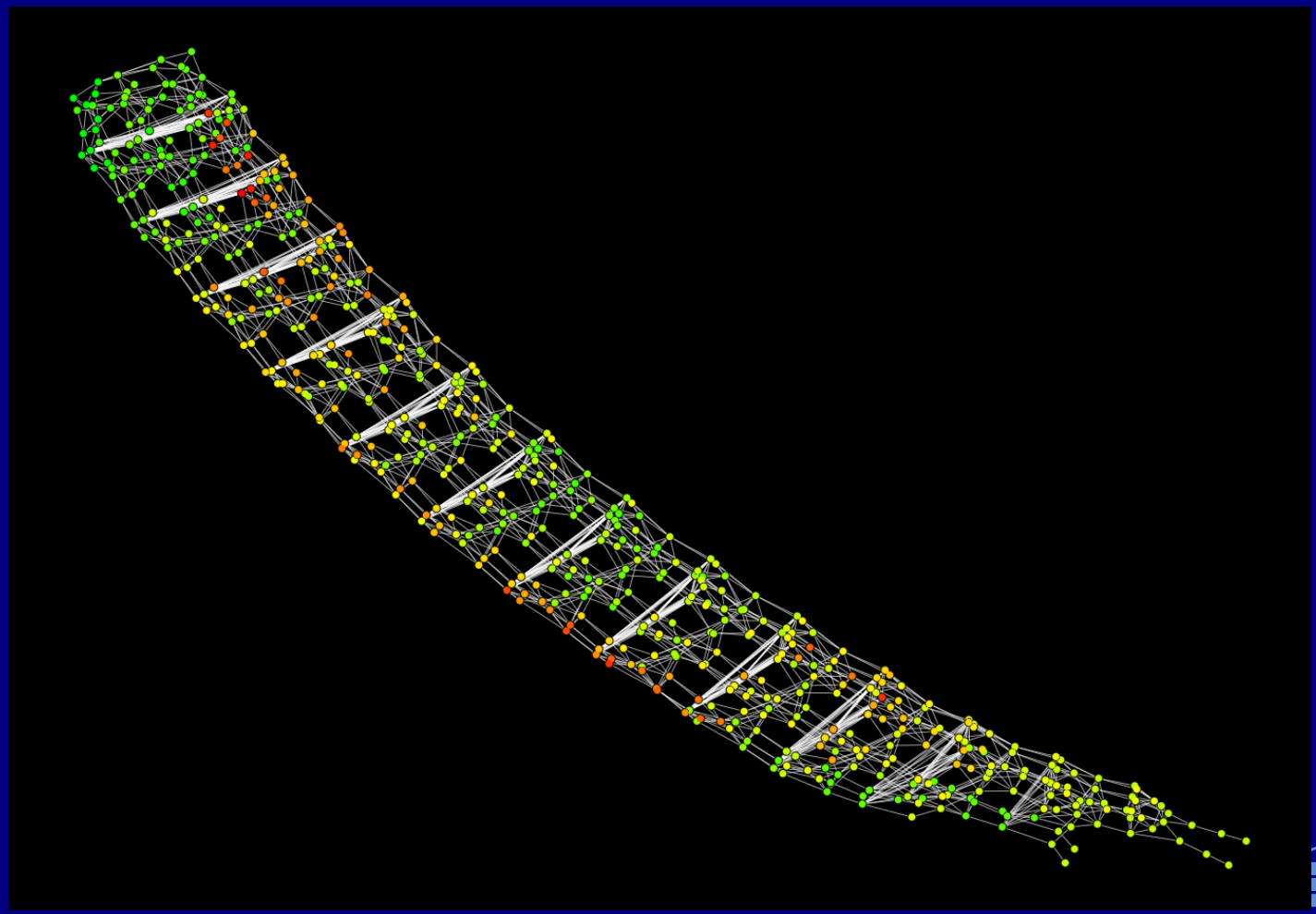
Visualization Examples

8-Queens: program interaction graph



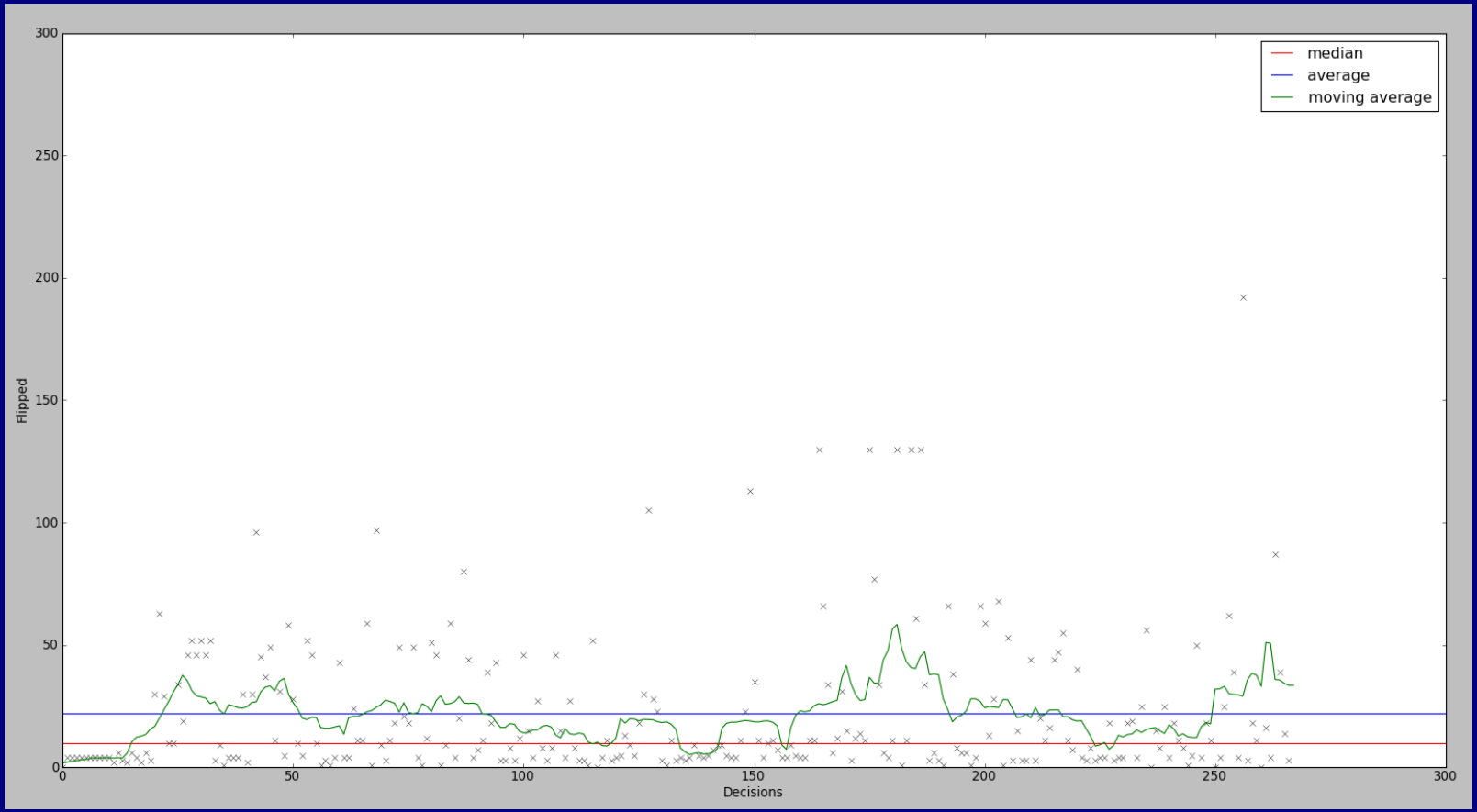
Visualization Examples

Towers of Hanoi: program interaction graph
Colors showing flipped assignments



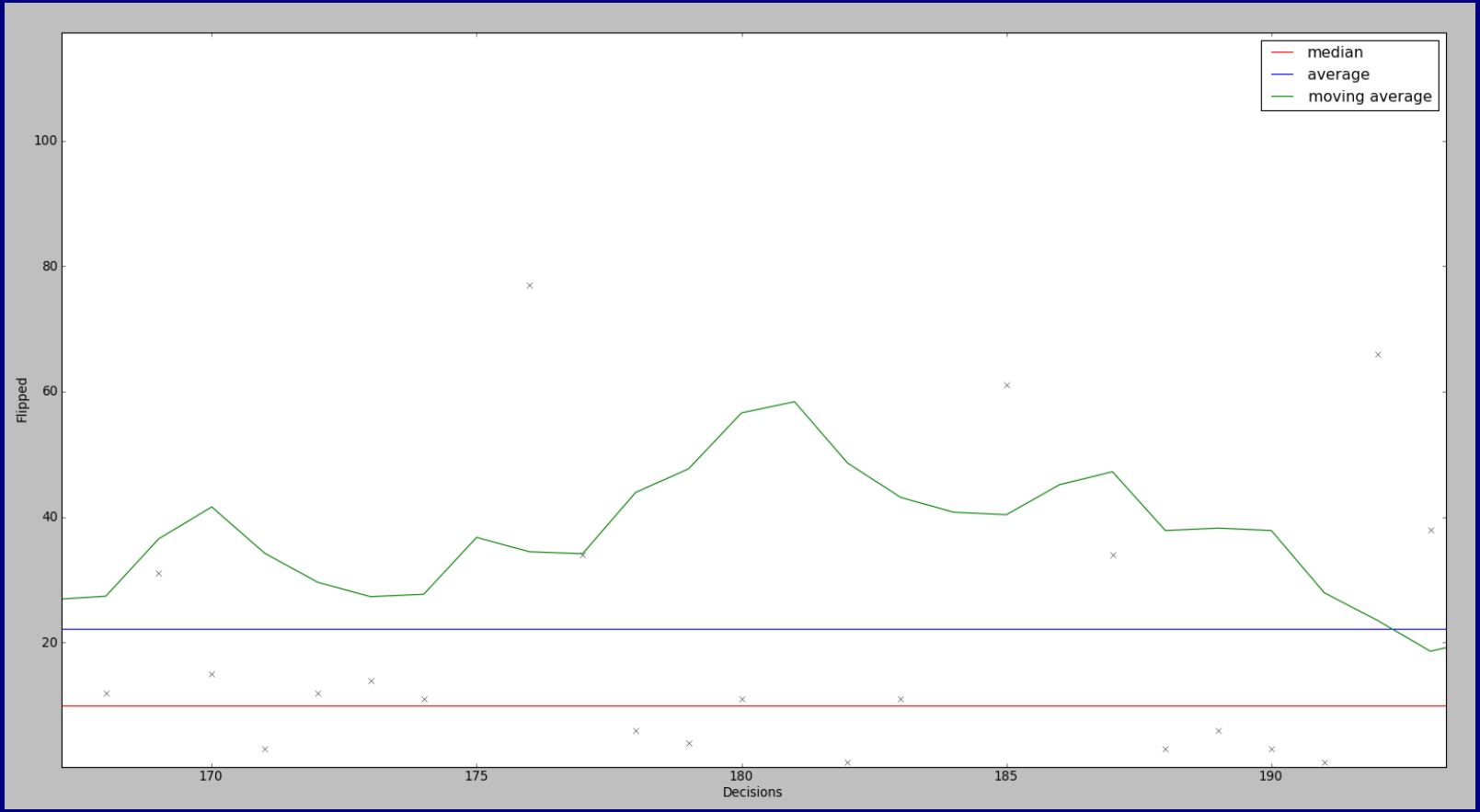
Visualization Examples

Towers of Hanoi: flipped assignments between decisions



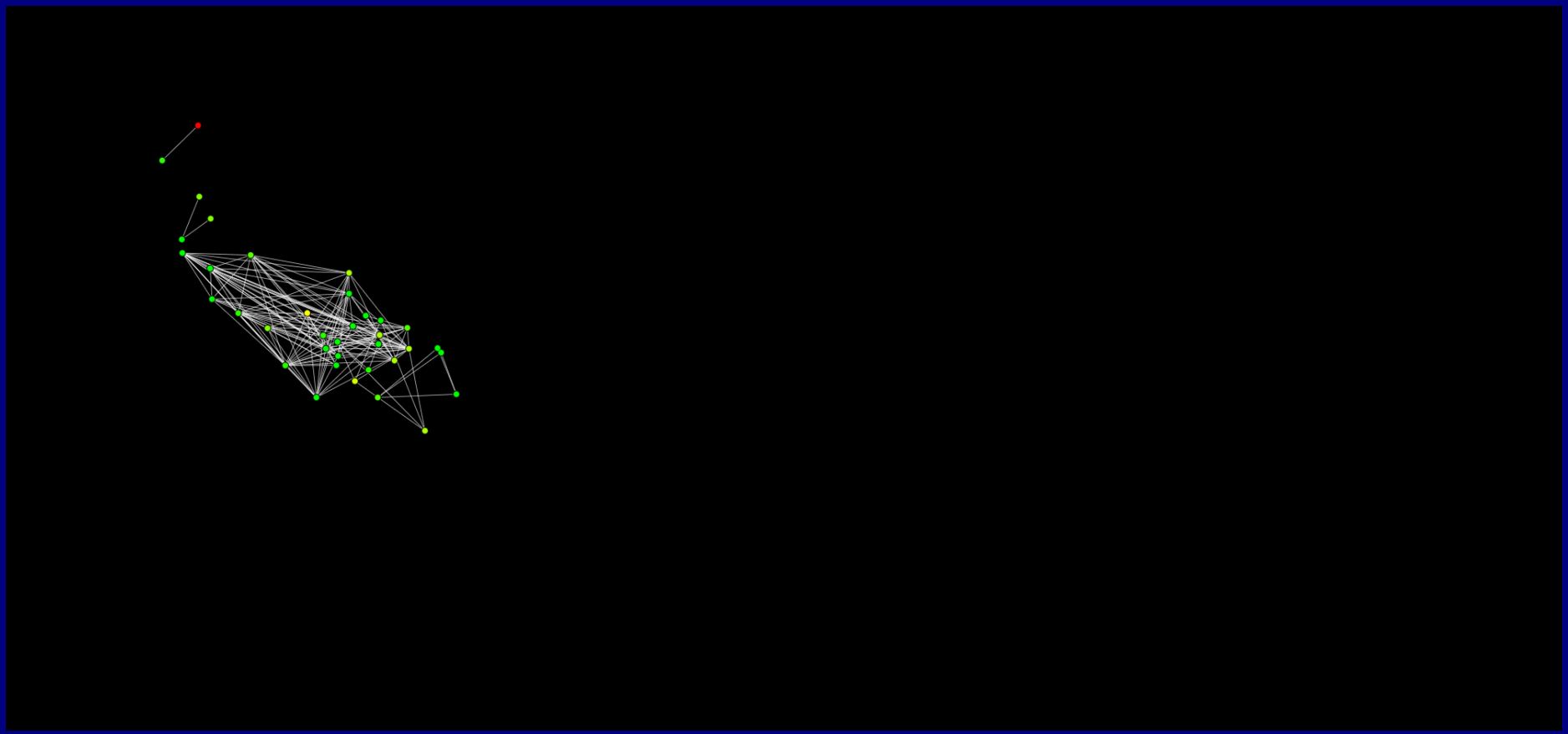
Visualization Examples

Towers of Hanoi: flipped assignments between decisions (zoomed in)



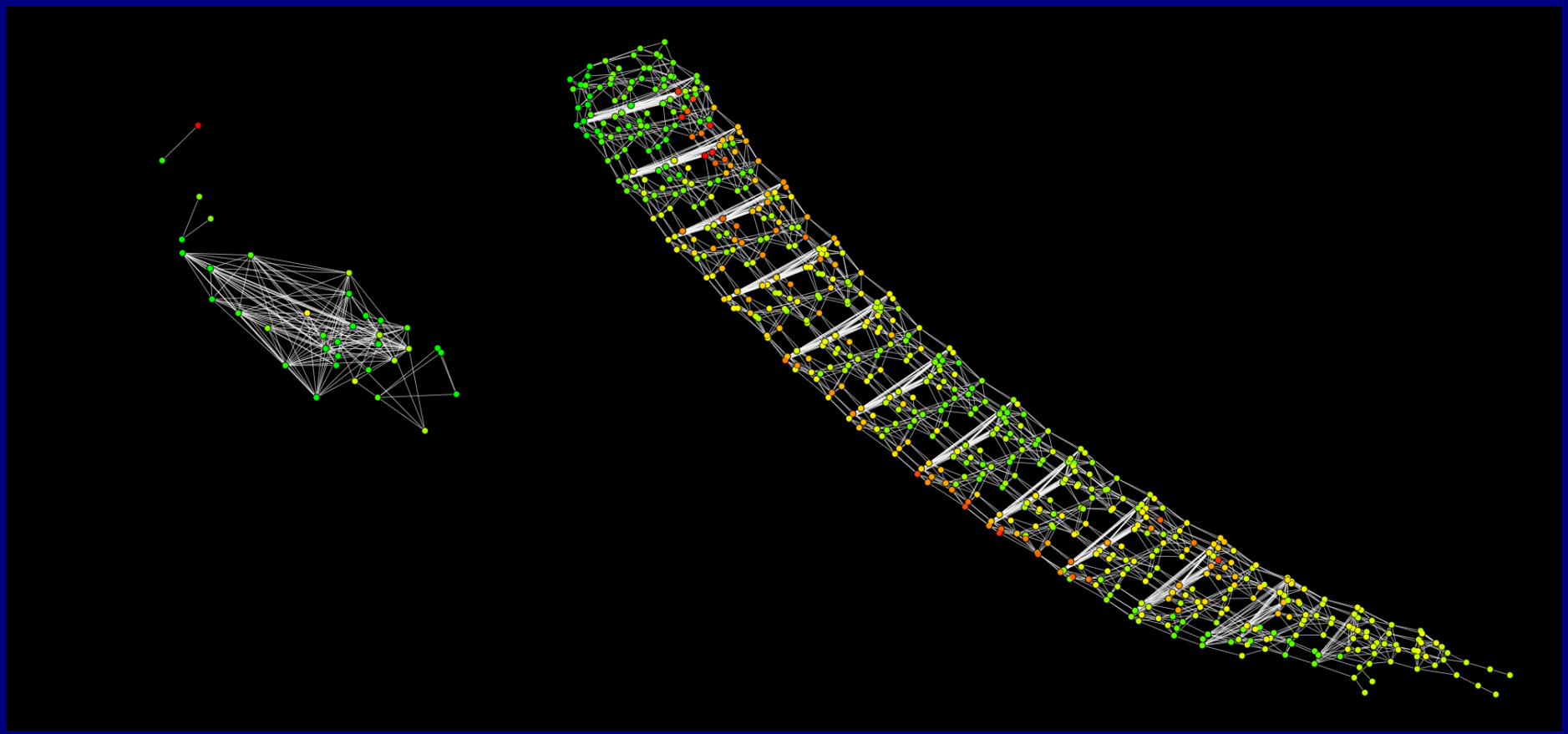
Visualization Examples

Towers of Hanoi: learned nogoods during zoomed in segment projected onto program interaction graph layout

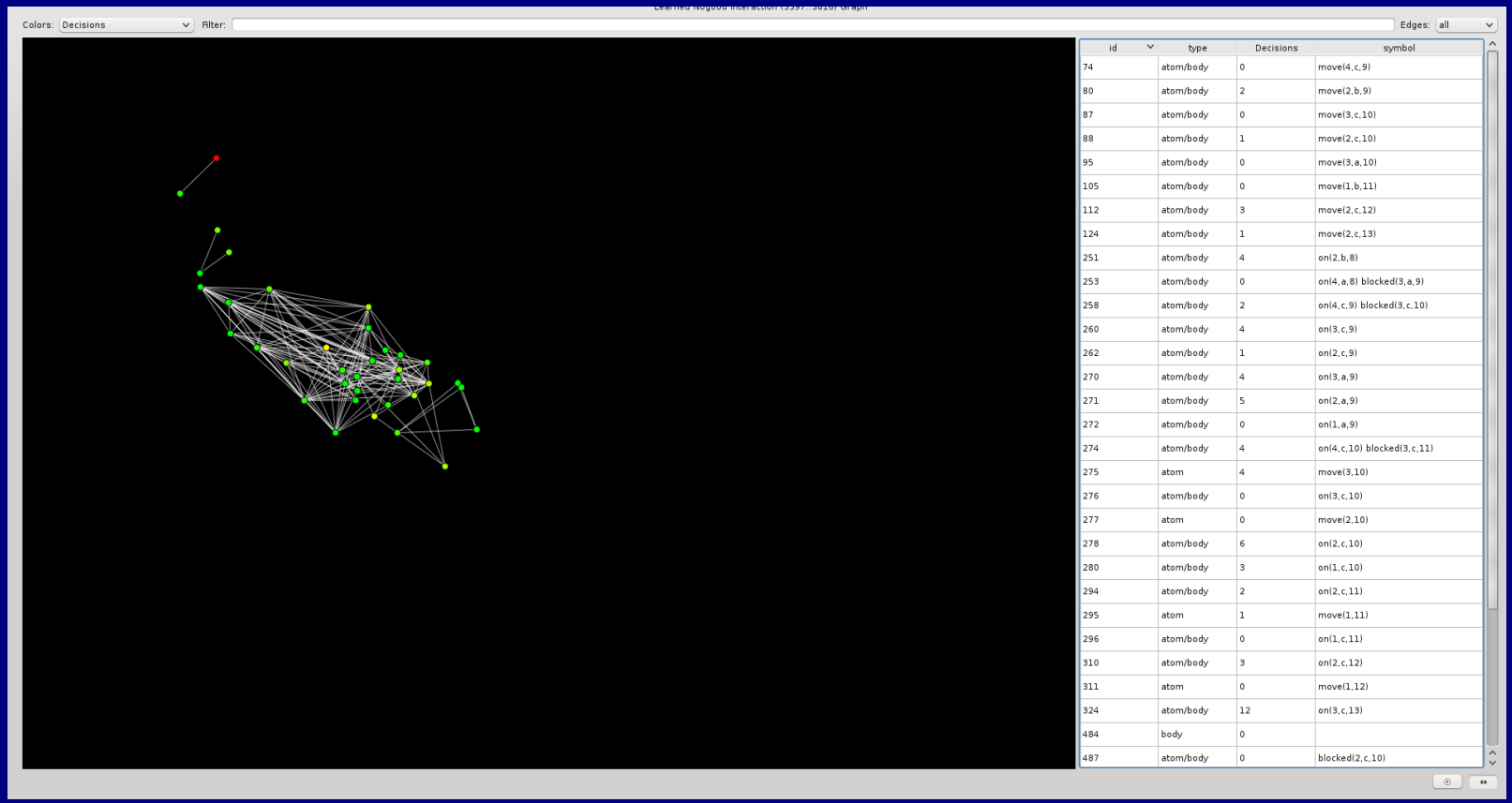


Visualization Examples

Towers of Hanoi: learned nogoods during zoomed in segment compared to program interaction graph



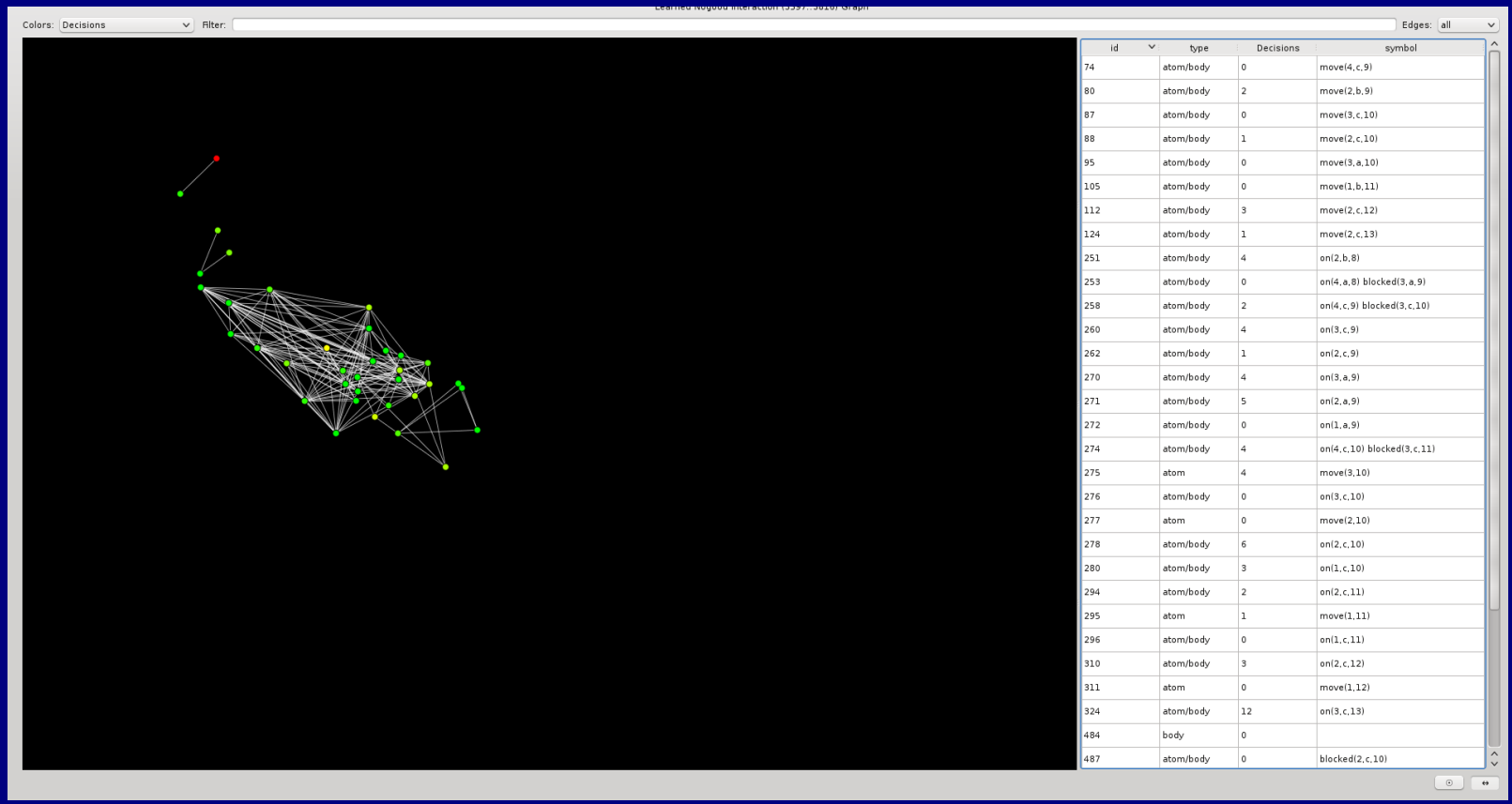
Interactive View



- Symbol table shows additional information about variables
- Search bar and symbol table allow for dynamic change of the view

Potassco

Interactive View



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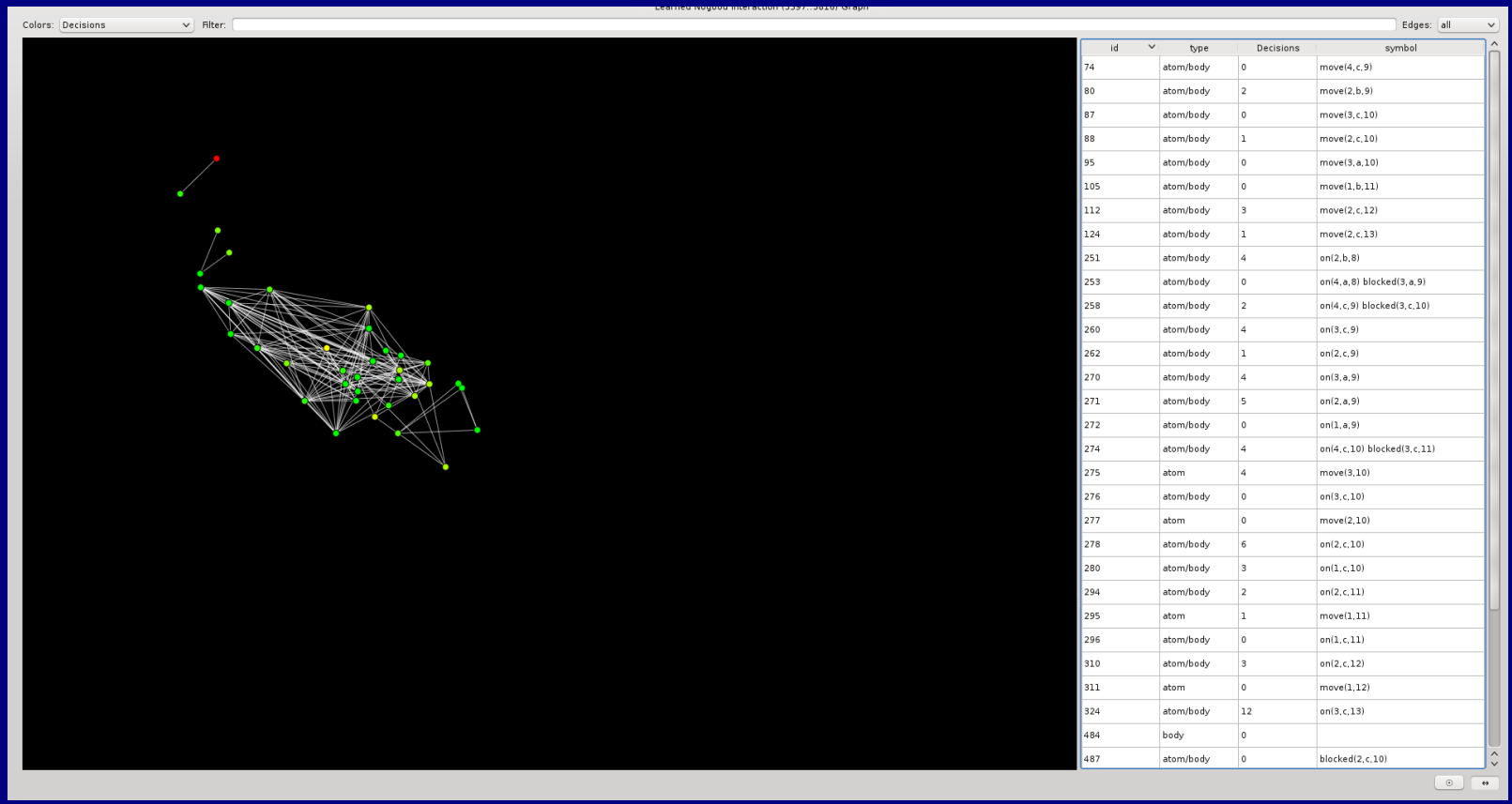
Potassco

Interactive View



- Symbol table shows additional information about variables
- Search bar and symbol table allow for dynamic change of the view

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